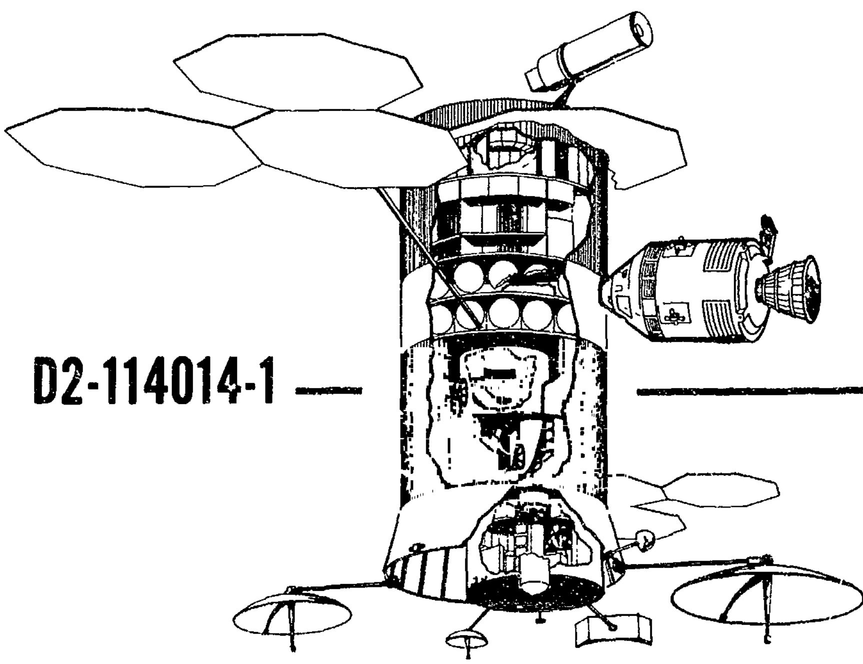
SATURN V SINGLE LAUNCH SPACE STATION AND OBSERVATORY FACILITY

COMBINED MISSION CONCEPT EVALUATION



D2-114014-1

THE BOEING COMPANY
AERO SPACE GROUP
SPACE DIVISION
SEATTLE, WASHINGTON

PREPARED FOR
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER, HOUSTON, TEXAS
UNDER CONTRACT NAS9-6816

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Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
Houston, Texas

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PREFACE

This document constitutes one volume of the final report under Contract NAS9-6816, Saturn V Single Launch Space Station Study. The study was conducted by the Space Division of The Boeing Company under the direction of the Manned Space Station Office, Advanced Spacecraft Technology Division, Manned Spacecraft Center. The study has two major segments, corresponding to the initial (or basic) contract, and the addendum to the study contract. The basic study involved development of an economical, early availability, Earth-orbital space station using a Saturn V launch vehicle; in the addendum study, the feasibility of using interplanetary spacecraft hardware for an Earth-orbital space station was examined. The latter was designed for an Earth-orbital experimental program, but was also used in development testing for the Mars mission; hence, its mission is called the "combined mission."

The documents constituting the basic final study report are:

- D2-113535-1, Condensed Summary---Basic Study;
- D2-113536-1, Technical Summary---Basic Study;
- D2-113537-1, Earth-Orbital Mission Requirements;
- D2-113538-1, Earth-Orbital Station Utilization;
- D2-113539-1, Earth-Orbital Station Design;
- D2-113540-1, Earth-Orbital Station Program Plans and Cost.

The final documents in the addendum study are:

- D2-114011-1, Condensed Summary---Addendum Study;
- D2-114012-1, Technical Summary---Addendum Study;
- D2-114013-1, Combined Mission Requirements;
- D2-114014-1, Combined Mission Concept Evaluation;
- D2-114015-1, Combined Mission Station Design;
- D2-114016-1, Combined Mission Program Plans and Cost.

DOCUMENT COVERAGE MATRIX

	BASIC STUDY						ADDENDUM STUDY					
	D2-113535-1 Condensed Summary	D2-113536-1 Technical Summary	D2-113537-1 Earth-Orbital Mission Requirements	D2-113538-1 Earth-Orbital Station Utilization	D2-113539-1 Earth-Orbital Station Design	D2-113540-1 Earth-Orbital Station Program Plans & Cost	D2-114011-1 Condensed Summary	D2-114012-1 Technical Summary	D2-114013-1 Combined Mission Requirements	D2-114014-1 Combined Mission Concept Evaluation	D2-114015-1 Combined Mission Station Design	D2-114016-1 Combined Mission Program Plans & Cost
REQUIREMENTS												
Mission Profile	X	X	●	X		X	X	X	●		X	X
Design Requirements		X	●		X			X	●		X	
Environments			●			X			●			
Crew Rotation								X	●			
EXPERIMENTS												
Experiment Definition	X	X	●	X	X			X	●	X	X	
Experiment Integration	X	X	X	●	X	X	X	X	X	●	X	X
CONFIGURATION												
Selected Design	X	X		X	●	X	X	X	●	X	●	X
Manning and Resupply	X	X	X		●	X	X	X	X			X
Alternative Approaches	X	X			●			X		X		
Artificial Gravity		X			●			X				
Trade Studies		X		X	●			X		X		
Structures and Weights	X	X			●	●	X	X	●	●	●	
Radiation Analysis	X	X	X		●		X	X	X			
Thermal Analysis					●						●	
Mars Flyby Baseline							X	X	X	X	●	X
SUBSYSTEMS												
Electrical Power	X	X			●	X	X	X			●	X
Environmental Control/ Life Support	X	X			●	X	X	X			●	X
Stabilization and Control	X	X				X	X	X			●	X
Crew Systems	X	X			●	X	X	X			●	X
Communications and Data Mgt.	X	X			●	X	X	X			●	X
Instrumentation	X	X			●	X	X	X			●	X
Propulsion	X	X			●	X	X	X			●	X
Subsystem Reliability	X	X		●	X	X	X	X			●	X
Existing Equipment Sources					X	●						
UTILIZATION												
Crew Size and Skills	X	X	X	●	X		X	X	X	●	X	
Timeline Analysis	X	X		●			X	X		●		
Experiment Capability	X	X		●	X		X	X		●	X	
Maintenance and Reliability	X	X		●	X		X	X		●	X	
PROGRAM PLANS												
Engineering Plan	X	X				●	X	X				
Test Plan	X	X				●	X	X	●	●	●	●
Manufacturing Plan	X	X				●	X	X	●	●	●	●
COSTS	X	X				●	X	X				●

● Primary Coverage

X Summary or Secondary Coverage

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1.0 INTRODUCTION

The purpose of the study was to determine if it is technically possible and programmatically practical to accomplish a combined mission in Earth orbit to develop a significant segment of a Mars mission spacecraft while conducting an Earth orbital experiment program.

This document contains a description of the experiment capability of the candidate and selected combined mission configurations, the value of the combined mission to the Mars flyby mission, crew utilization, reliability and maintenance.

The experiment capability includes a discussion of the manhours, weight, and volume capabilities of the configurations and a description of the experiment objectives that can be accomplished with each configuration.

The value of the combined mission was determined on the basis of the similarity of the mission operations, equipment and environments. The advantages of the early development flight were determined.

The crew utilization includes the basic crew schedule, skills, and a comparison of the crew effectiveness for a 10- and 12-hour work day. The 10-hour work day provides approximately eight hours experimentation per day while the 12-hour work day provides approximately ten hours experimentation.

The reliability and maintenance discussion includes a description of the computer model, identification of the maintenance activities, success criteria, and results of the reliability and maintainability analyses.

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2.0 SUMMARY

The results of the experiment capability, contribution of the combined mission, crew utilization, reliability, and maintenance analyses are summarized in the following sections. An eight-man crew configuration was selected which provides a capability in excess of that required to accomplish the Earth orbit experiment program and simulation of critical flyby operations. The selected configuration provides the equivalent of two development missions in testing on the EC/LS and crew systems with a 99 percent probability of successful operation for two years.

2.1 EXPERIMENT CAPABILITY

The capability of the combined mission configurations to perform the NASA Headquarters Time-Phased Earth Orbit Experiment program was determined on the basis of the manhour, weight, and volume capacities of each configuration. The five alternate configurations discussed in Document D2-114015-1, Section 3.0 were evaluated. Approach I is a four-man configuration which is as similar to the flyby mission module as possible. Approach II is essentially two of these modules attached to form a space station. Approach III is the same as Approach II except the modules are not attached. Approach IV is the four-man module attached to a new module designed for Earth orbital operation but using as many Mars flyby mission module systems as practical. Two versions of Approach IV were studied, one with two men in the new module (total crew size, 6), and one with four men in the new module (total crew size, 8).

Only the Approach IV (eight men) configuration was found to be capable of meeting all of the requirements of the experiment program. The Approach IV (six men) configuration can meet all requirements except that for manhours. This requirement could be met if the crew were to work a 12-hour day rather than a 10-hour day. The Approach I, II, and III configurations cannot meet all the experiment requirements even if the work day is increased and the total payload capability of the manning and logistics vehicles is utilized. For this reason the eight-man Approach IV configuration was selected for the combined mission.

The selected configuration provides the necessary experiment capacity and in addition offers the advantage that a four-man crew can be isolated to determine the psychological effect of a long-duration flight without degrading experiment accomplishment.

2.2 VALUE OF COMBINED MISSION TO FLYBY MISSION

The combined mission significantly contributes to the development of flyby hardware and operational procedures. Critical flyby mission activity periods can be simulated to determine their feasibility. The flyby hardware can be tested for the two-year duration in essentially the same environment as will be encountered during the flyby mission. An analysis of the development test capability showed that all flyby equipment would be tested except the Mars probes, biological laboratory, and Earth entry module.

2.3 CREW UTILIZATION

A basic crew schedule was developed for an eight-man crew so crewmen with compatible skills could perform experiments during the same shift. All biomedical and behavioral experiments were scheduled to coincide with the Medical Doctor's work schedule.

Timeline analyses were performed to determine the effectiveness of the eight-man crew. The idle time of the crewmen increases when the crew size is changed from six (basic study) to eight, but all experiments can be accomplished. Table 2.3-1 summarizes the time spent on activities and experiments using the recommended 10-hour work day.

2.4 RELIABILITY AND MAINTENANCE

A reliability and maintainability analysis was performed to determine the maintenance time and spares required for the combined mission. The mean repair time for unscheduled maintenance was found to be 0.58 hours crew time per day. The crew time required for scheduled maintenance is 2.9 hours per day. The worst-case condition which was studied was a 14-hour unscheduled maintenance activity combined with 2.9 hours of scheduled maintenance in one day.

The MARCEP program was used to perform a maintenance analysis of the selected configuration subsystems. The results of the analysis are shown in Figure 2.4-1. The weight of replacement spares carried on the mission for different resupply periods is shown for a 0.99 probability of having the right spare part or component available when needed. For comparison, a second bar indicates the maximum spares weight expected to be used during these resupply periods.

TABLE 2.3-1: CREW EXPERIMENT ASSIGNMENTS SUMMARY
(30 Day Time Line; 150 Minutes/Day, Free Time)

ACTIVITY OR EXPERIMENT AREA	CREW TIME ASSIGNMENT Percent							
	A	B	C	D	E	F	G	H
ACTIVITIES								
Sleep	31	31	31	31	31	31	31	31
Exercise & Free Time	12	12	12	12	12	12	12	12
Personal Hygiene & Meals	15	15	15	15	15	15	15	15
Station Management and Maintenance	8	8	8	8	8	8	8	8
EXPERIMENT AREA								
Biomedical/Behavioral	6	6	30	16	6	6	6	6
Bioscience				10	24			
Astronomy/Astrophysics		14				27		13
Earth Resources		5						5
Atmospheric Sciences		8						9
Physical Sciences	15							
Advanced Technology	7						7	
Communications/Navigation	4						4	
Manned Space Operations	1						1	
Idle Time	1	1	4	8	4	1	3	1
TOTAL	100	100	100	100	100	100	100	100

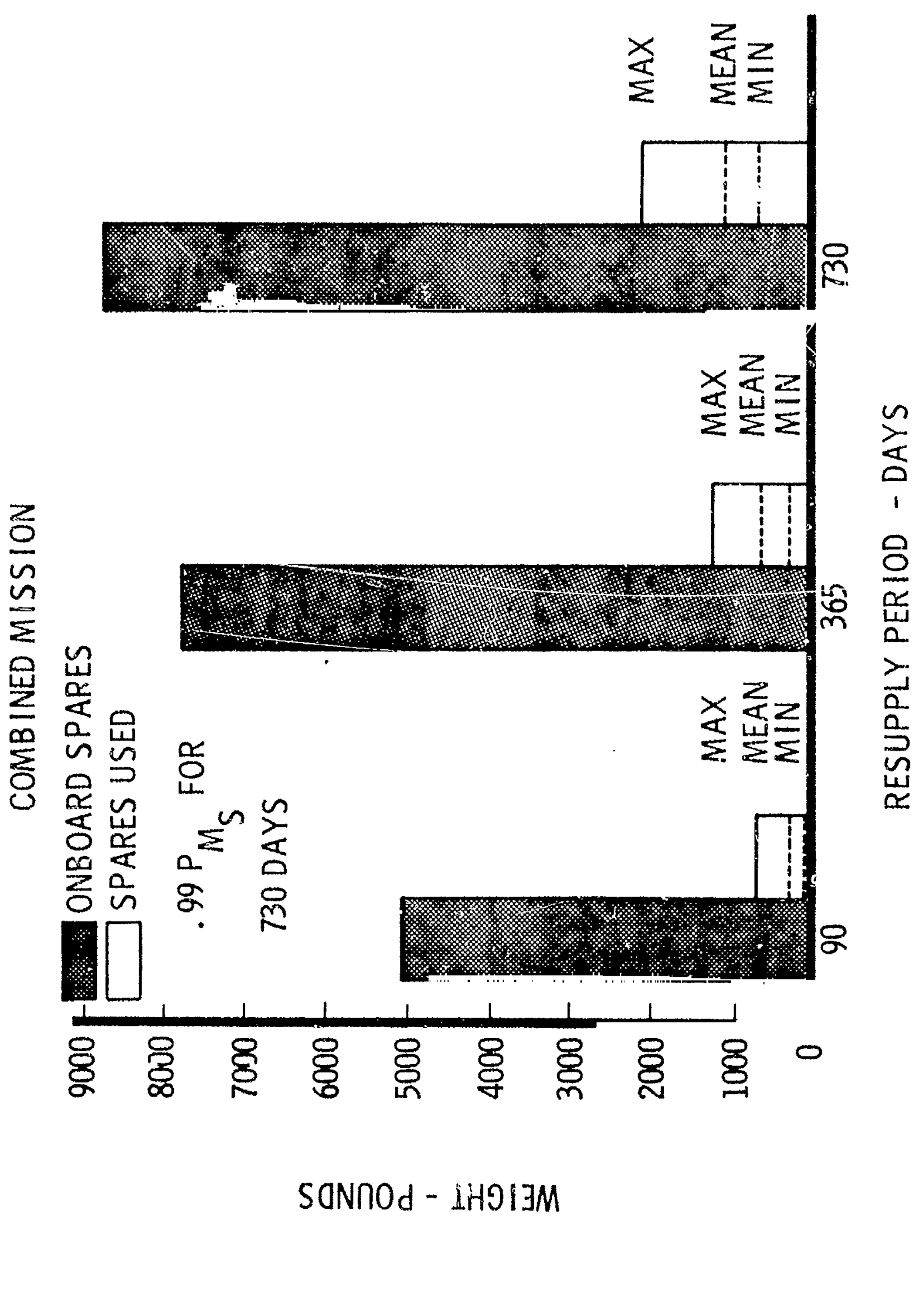


Figure 2.4-1: SPARES VS RESUPPLY PERIOD

3.0 EXPERIMENT CAPABILITY

The capability of the combined mission configurations to perform the NASA headquarters time-phased Earth orbit experiments was determined on the basis of available manhours, weight, and volume. Each configuration was analyzed to identify the experiment equipment that could be installed within the available weight and volume. An analysis was also performed to determine the time available for experiments with each configuration. The 8 man-approach IV configuration was found to be capable of satisfying all the earth orbital experiment requirements and to provide excess volume, weight and manhours which allows for considerable flexibility in the experiment program.

3.1 EXPERIMENT TIME AVAILABILITY

The time availability for experiments was based on a 10 hour work day and a 7 day work week. The time available for experiments is the difference between the hours required for station duties and the hours in the work day. Station duties consist of housekeeping, scheduled maintenance, unscheduled maintenance, and station management. The average time required for station duties is a function of the size of the crew and the configuration. The time allocated for housekeeping station management, and maintenance is shown in Table 3.1-1. Station management was considered as a constant (63 hours per week) for all configurations except Approach III. Approach III has two modules which orbit separately and perform different missions and therefore requires twice the number of manhours for station management. Housekeeping functions include general station cleaning and food preparation--this was assumed to be a constant for each man (4.5 hours per week). The maintenance tasks are a function of the subsystems onboard the configuration. The approach I configuration has one set of subsystems while approaches II and IV have an additional EC/LS and crew subsystem. This increases the maintenance time for these configurations by approximately 90 percent. Approach III has two complete sets of subsystems which require twice as much maintenance time as Approach I. The distribution of station duties for each configuration approach is shown in Figure 3.1-1.

The hours available for experiments was computed on the basis of total work hours per week minus the time required for station duties. The resulting experiment hours are shown in Table 3.1-2. Configuration Approaches II, III, and IV (8 men) provide enough experiment hours to allow accomplishment of all the Earth orbital experiment objectives.

3.2 CONFIGURATION EXPERIMENT CAPACITY

The configurations were analyzed to determine the volume and weight available for Earth orbital experiments. The available volume and weight is summarized in Table 3.2-1.

TABLE 3.1-1
TIME REQUIRED FOR STATION DUTIES

CONFIGURATION APPROACH	CREW SIZE	TIME REQUIRED ~ HOURS/WEEK				
		STATION MANAGEMENT	HOUSEKEEPING	MAINTENANCE		TOTAL
				SCHEDULED	UNSCHEDULED	
I	4	63	18	10.5	2.0	93.6
II	8	63	36	20.1	3.5	122.6
III	8	128	36	21.0	4.0	189.0
IV(6 men)	6	63	27	20.1	3.5	113.6
IV(8 men)	8	63	36	20.1	3.5	122.6

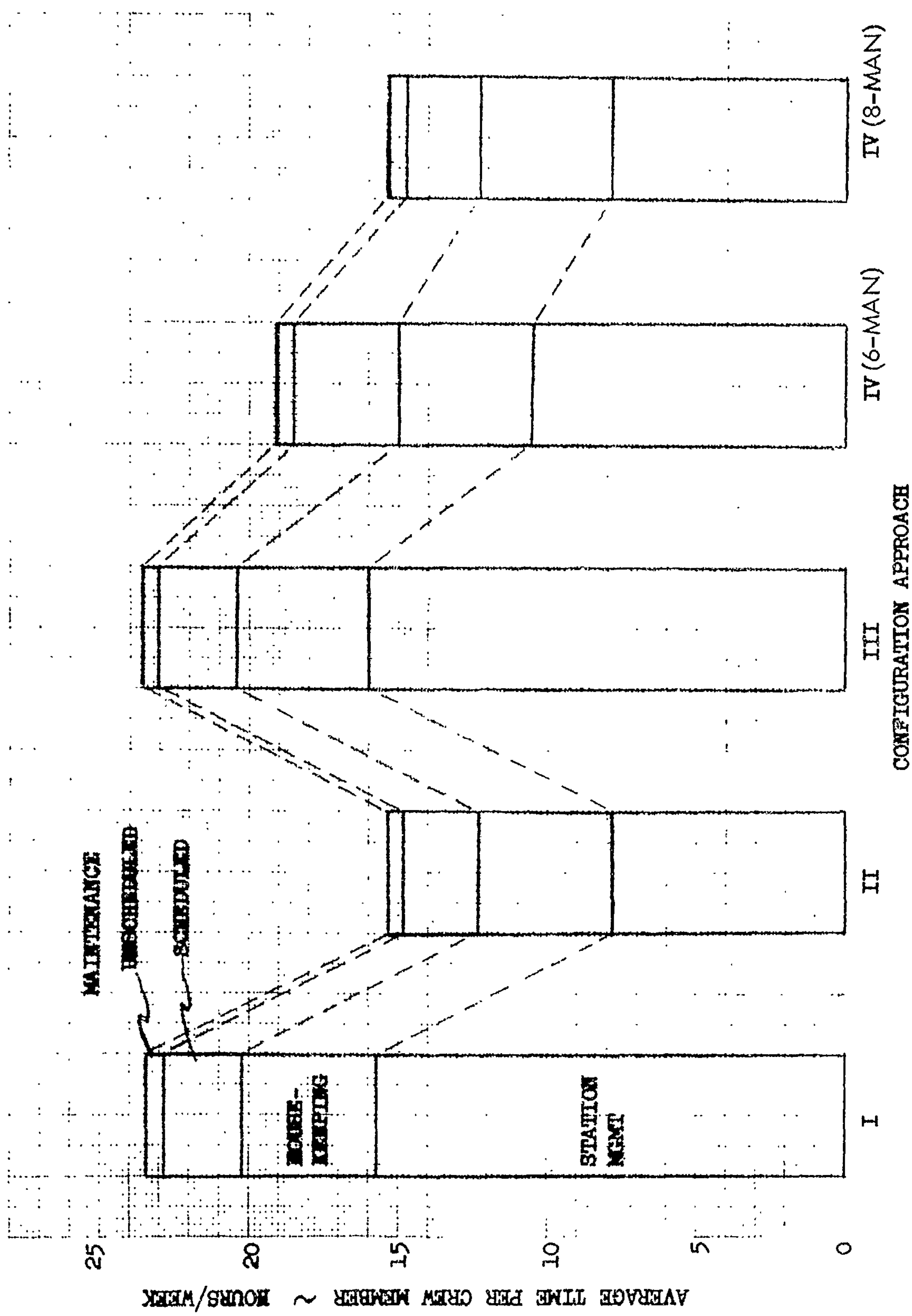


Figure 3.1-1: AVERAGE TIME REQUIRED FOR STATION DUTIES

TABLE 3.1-2 AVAILABLE EXPERIMENT HOURS

CONFIGURATION	CREW EXPERIMENT HOURS		
	DAY	WEEK	YEAR
APPROACH I	26.6	186.4	9,693
APPROACH II	62.3	436.1	22,745
APPROACH III	53.2	372.4	19,365
APPROACH IV (6 men)	43.8	306.6	15,943
APPROACH IV (8 men)	62.5	437.4	22,745

TABLE 3.2-1 AVAILABLE VOLUME AND WEIGHT

CONFIGURATION	WEIGHT LB*	VOLUME FT^3	
		PRESSURIZED	UNPRESSURIZED
APPROACH I	28,170	275	3,760
Initial	23,820		
Manning	4,358		
APPROACH II	53,555	1,248	8,912
Initial	44,855		
Manning	8,700		
APPROACH III	38,516	550	7,808
Initial	29,816		
Manning	8,700		
APPROACH IV (6 men)	77,636	4,250	12,780
Initial	68,936		
Manning	8,700		
APPROACH IV (8 men)	63,759	4,450	11,235
Initial	54,666		
Manning	8,700		

The required experiment weight for the two-year mission is 63,460 pounds. However, film must be resupplied every 90 days so the maximum experiment weight for mission initiation will be 56,460 pounds. This weight can be split between the space station launch and the manning launches. The pressurized volume required for stowed experiments is 4,079 cubic feet (974 for equipment; 3,105 for work areas). The unpressurized volume

* Initial space station launch and manning launches; one manning launch (4,358 lbs) for Approach I, two manning launches (8,700 lbs) for all other approaches.

required for stowed experiments is 1,707 cubic feet.

3.3 EXPERIMENT CAPABILITY OF ALTERNATE CONFIGURATIONS

The capability of each configuration approach to meet the objectives of the Earth orbital experiment program was determined on the basis of the number of experiment objectives that could be performed within the available capacity of the configurations. Experimental equipment was placed in the configurations to utilize as much of the capacity shown in the previous sections as was possible. This analysis was performed at a gross level of detail since its purpose was to define the comparative experiment capability of the alternatives, not to optimize each alternative. The factors used in the analysis were manhours, weight, and volume available for experiments.

Table 3.3-1 summarizes the results of the analysis. The table shows only the limiting factors of each configuration in terms of negative margins; where a positive margin exists, no entry was made in the table. The table shows that all configurations have limited capacity for experiments except Approach IV (8 men). The only limitation on Approach IV (6 men) was manhours. This is the same limitation that was found to exist when using the 33-foot diameter, six-man space station of the basic Saturn V Single Launch Space Station study. However, the limitation was considered more severe for this application because it is a more advanced mission, Mars flyby simulations should be performed in addition to the Earth orbital program, and the crew is split into the two sections of the space station. The Approach IV (8 men) configuration was therefore selected as the preferred configuration for this study. The following sections describe the experiment capability of each configuration in more detail.

TABLE 3.3-1 CONFIGURATION EXPERIMENT LIMITATIONS

	EXPERIMENT LIMITATIONS			
			VOLUME	
CONFIGURATION	MANHOURS	WEIGHT	PRESSURIZED	UNPRESSURIZED
APPROACH I	-7,900	-28,290	-3,804	
APPROACH II		-2,905	-2,831	
APPROACH III		-17,944	-3,529	
APPROACH IV (6 men)	-1,369			
APPROACH IV (8 men)				

3.3.1 APPROACH I CAPABILITY

Approach I is identical in exterior shape to the flyby configuration. The configuration has sufficient unpressurized volume to accommodate all experiments but is severely lacking in pressurized volume. Table 3.3-2 summarizes the experiment capability of this configuration. The configuration has the capability to accomplish 45 percent of the Earth orbit experiment activities providing they can be accomplished using severely limited work areas.

TABLE 3.3-2 APPROACH I EXPERIMENT CAPABILITY

		REQUIRED EXPERIMENT CAPACITY				
			WEIGHT	VOLUME ~ ft3		
			lbs	PRESS.		UNPRESS.
EXPERIMENTS	ACTIVITIES	MANHOURS	[1]	STOWED EQUIP.	WORK AREAS	
ASTRONOMY/ ASTROPHYSICS	16	4,374	12,210	34	600	466
BIOMEDICAL/ BEHAVIORAL	58	3,139	359	25	600	--
PHYSICAL SCIENCE	31	720	2,058	50	600 (Physical Science and Communications/Navigation combined)	59
COMMUNICATIONS/ NAVIGATION	21	518	6,711	31		636
FLYBY SIMULATION		852	--	--	--	--
TOTAL	126	9,603	21,338	140	1,800	1,161
REMAINING CAPABILITY		90	6,832	135	[2] -1,665	2,599
EXCESS FOR TOTAL E.O. EXPER. PROGRAM		-7,900	-28,290	-699	-3,105	1,953

[1] Carried on space station and/or manning launches.

[2] Assuming the 135 cubic foot excess stowed equipment volume would be used as work area.

The excess capability of this configuration is less than that required to accommodate the experiments in one of the other experiment areas. All the experiments are performed in the experiment areas shown in the table. The 852 hours for flyby simulation will allow the crew to simulate the high activity period of the flyby mission which occurs prior to and after encounter. Time is also included for evaluation of the flyby equipment. 126 total activities are included in the experiment categories shown. This is approximately 45% of the total activities (287).

3.3.2 APPROACH II CAPABILITY

The Approach II configuration has an 8 man crew and is capable of accomplishing 73 percent of the Earth orbit experiment activities. A summary of the experiments included in this configuration is shown in Table 3.3-3.

The pressurized volume shown for the experiments is only for installed equipment. The excess volume shown will be used as work area and therefore cannot be used to add other experimental equipment. The configuration would be capable of accommodating other experiments if more pressurized volume were available.

3.3.3 APPROACH III CAPABILITY

The Approach III configuration is similar to Approach II except the two spacecraft modules are separated in orbit to conduct separate missions. This configuration is limited in pressurized volume and weight so only 61 percent of the experiment activities can be accomplished. Table 3.3-4 summarizes the experiments placed onboard the configuration. The excess pressurized volume is required for work space so that additional equipment could not be added even if the weight capability were available.

3.3.4 APPROACH IV CAPABILITY (6 MEN)

The 6-man Approach IV configuration can accommodate all the Earth orbit experiments. To accomplish all the experiment activities the 6-man crew must work approximately 11 hours per day throughout the mission. Since this is more than the recommended work day (10 hours) this configuration was not selected. If the experiment program is changed prior to the mission so that the crew time is decreased this configuration would be an attractive contender.

3.3.5 APPROACH IV (8 MEN)

The 8-man Approach IV configuration has the capability to accommodate all the experiments. This configuration shows the most cost-effective weight margin and provides for a reasonable work schedule. In addition, psychological isolation-testing of the two four-man crews can be conducted without impairing the experiment program.

This configuration is shown in Figure 3.3-1 and is a 22-foot diameter spacecraft launched, unmanned, by a two-stage (S-IC/S-II) launch vehicle. The pressurized section of the spacecraft is composed of two modules, each having two decks. The forward module is outfitted to support a crew of four and to accomplish Earth orbital experiments. The aft module is a basic building block. A camera module is attached to the aft bulkhead of the building block.

An unpressurized interstage structure surrounds the camera module, stowed solar panels, antennas, and Earth-oriented experiment sensors. The aft

TABLE 3.3-3 APPROACH II EXPERIMENT CAPABILITY

EXPERIMENTS	ACTIVITIES	REQUIRED EXPERIMENT CAPACITY				
		MANHOURS	WEIGHT lbs [1]	VOLUME ~ ft3 PRESS. STOWED EQUIP.	VOLUME ~ ft3 PRESS. WORK AREA	VOLUME ~ ft3 UNPRESS.
ASTRONOMY/ ASTROPHYSICS	16	4,374	12,210	34	600	466
ATMOSPHERIC SCIENCES	34	2,049	2,257	48		33
PHYSICAL SCIENCES	31	720	2,058	50		59
ADVANCED TECHNOLOGY & SUBSYSTEMS	47	1,534	9,619	87	600	424
MANNED SPACE OPERATIONS	4	215	1,180	23		49
COMMUNICATIONS/ NAVIGATION	21	518	6,711	31		636
BIOMEDICAL/ BEHAVIORAL	58	4,008	359	25	600	- -
FLYBY SIMULATION		852	- -	- -		- -
TOTAL	[2] 211	14,270	34,394	298	1,800	1,667
REMAINING CAPABILITY		8,475	19,161	950	[3] -850	7,245
EXCESS FOR TOTAL E.O. EXPER. PROGRAM		5,152	-2,905	-676	-2,155	7,205

[1] Carried on space station and/or manning launches.

[2] 73% of the 287 total activities.

[3] Assuming the 950 cubic feet excess for stowed equipment would be used for work area.

TABLE 3.3-4 APPROACH III EXPERIMENT CAPABILITY

EXPERIMENTS	ACTIVITIES	REQUIRED EXPERIMENT CAPACITY				
		MANHOURS	WEIGHT lbs (2)	VOLUME ~ ft3		
				PRESS STOWED EQUIP.	WORK AREA	UNPRESS
ASTRONOMY/ ASTROPHYSICS	16	4,374	12,210	34	600	466
ATMOSPHERIC SCIENCES	34	2,049	2,257	48		33
PHYSICAL SCIENCES	31	720	2,058	50		59
ADVANCED TECHNOLOGY AND SUB-SYSTEMS (4)	12	384	5,041	22	600	106
MANNED SPACE OPER.	4	215	1,180	23		49
COMMUNICA-TIONS/NAVI-GATION	21	518	6,711	31		636
BIOMEDICAL/ BEHAVIORAL	58	6,145	359	25	600	---
FLYBY SIMULATION		852	---	--		---
TOTAL	(3) 176	13,120	29,816	233	1,800	1,349
REMAINING CAPABILITY		6,245	8,700	317	(1) -1,483	6,459
ECESS FOR TOTAL E.O. EXPER. PROG.		1,772	-17,944	-424	-2,780	6,101

(1) Assuming the 317 cu. ft. excess for stowed equipment would be used for work area.

(2) Carried on space station and/or manning launches.

(3) 61% of the 287 total activities.

(4) Only 25% of these activities were included.

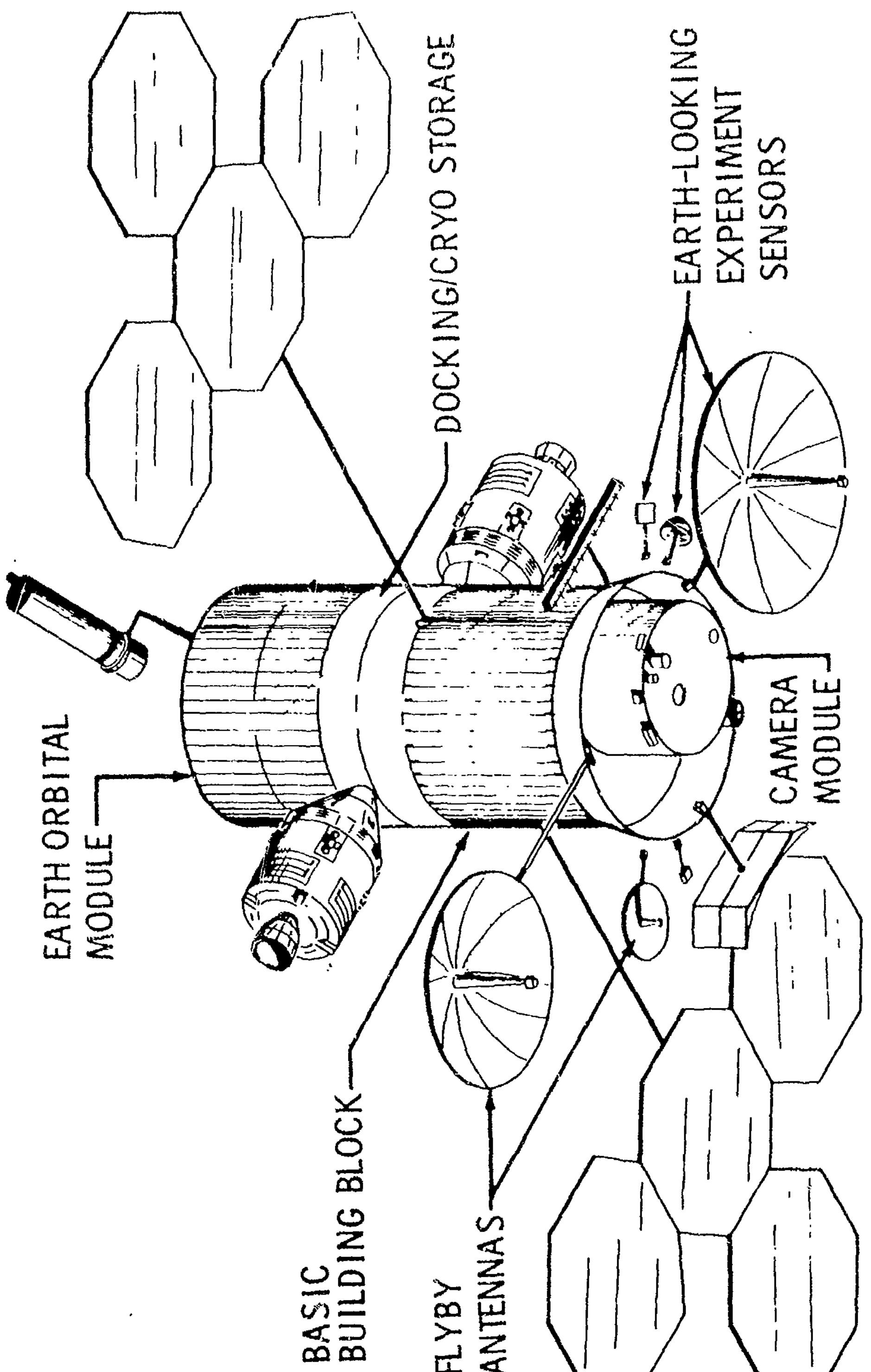


Figure 3.3-1: SELECTED CONFIGURATION

portion of the interstage is jettisoned in orbit, and panels, antennas, and sensors are deployed.

The telescopes mounted on the forward bulkhead are deployed for operation and are soft-mounted to eliminate disturbances from the spacecraft. They are provided with airlocks for film change, maintenance, and instrumentation changes.

The Earth orbital module as shown in Figure 3.3-2 provides the supporting subsystems and crew systems for a four-man crew in addition to provisions for a selected portion of the Earth orbital experiment program. The module is divided into two decks: an experiment deck and a living deck.

The experiment deck has a separately pressurizable 14.7-psia bioscience laboratory containing the experiment equipment that cannot be used in the 7.0-psia module environment. The laboratory also includes an independent ECS system. Access is provided by an airlock. Additional laboratory equipment is stored in the exterior area, which includes storage and equipment required to support the astronomy/astrophysics experiments. Individual airlocks supply access for film changing and telescope servicing.

Three sets of telescopes are installed on the forward experiment bay as shown in Figure 3.3-3. The Cassegrainian and Schmidt telescopes are separately mounted and the solar telescopes are mounted as a unit.

Each telescope is extended by a mechanism which positions the mount so that the telescope is pointing toward the selected target. This mechanism is then located to allow the soft-gimbal-mounted telescope attitude-control system to be operated for precise pointing and tracking.

Airlocks are provided within the experiment module to retrieve film and to change the associated equipment for the experiment program. This provision eliminates EVA activities for normal operation of the telescopes.

The 15-foot-diameter camera module as shown in Figure 3.3-4 is located on the aft end of the spacecraft and contains provisions for the Earth resources, physical sciences, and manned space and logistics experiments. Entry to the module is made through the EVA airlock. All preparations for EVA operations are conducted in the module.

The module has been oriented to give the maximum viewing capability for the Earth sensors. Other Earth-oriented sensors stowed in the unpressurized section aft of the camera module are deployed to provide unobstructed camera viewing.

The experiment capacity of this configuration is shown in Table 3.3-5. The unallocated margin for unpressurized volume, manhours, electrical power cooling, and resupply weight is sufficiently large to cover all contingencies and offer considerable flexibility to the experiment program.

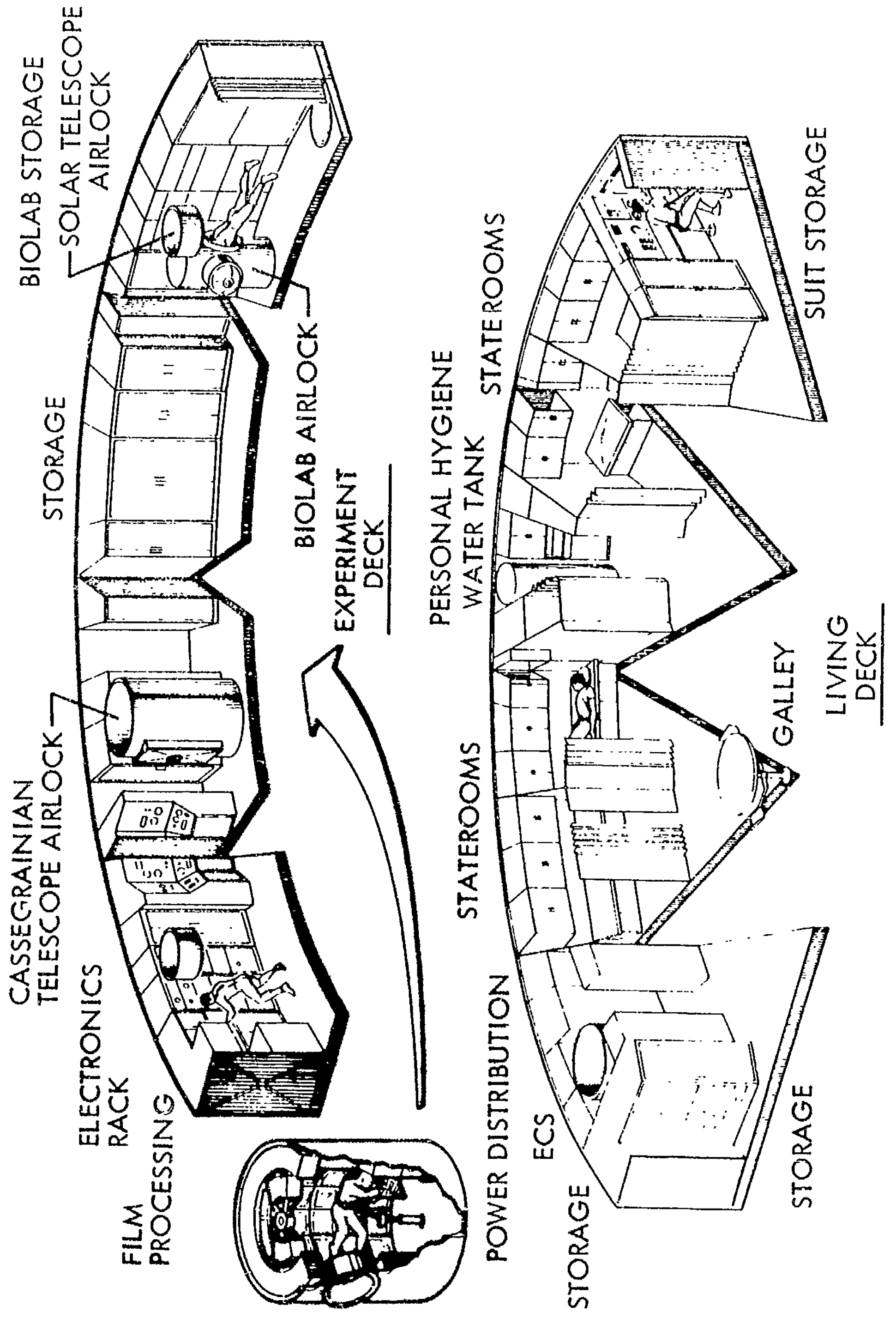


Figure 3.3-2: EARTH ORBITAL MODULE

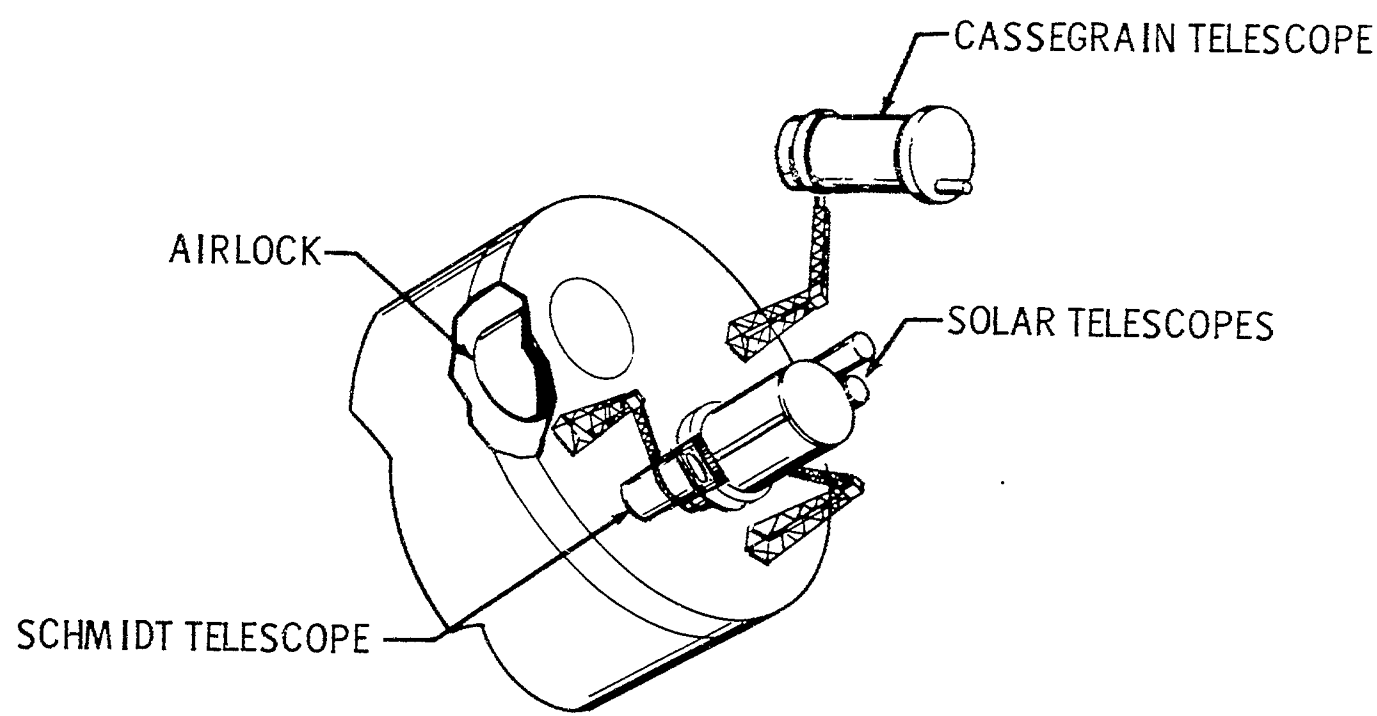


Figure 3.3-3: TELESCOPE MODULE

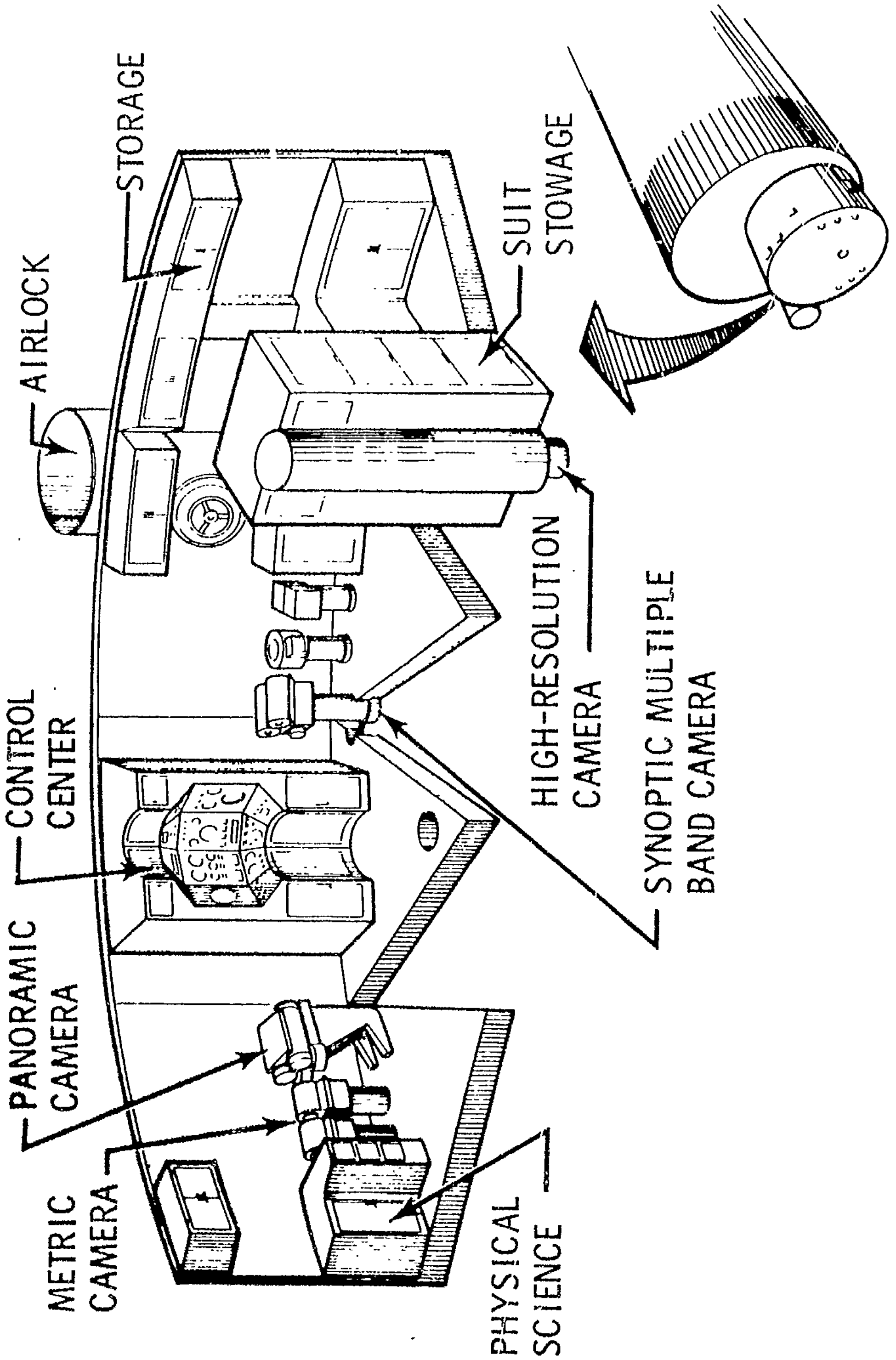


Figure 3.3-4: CAMERA MODULE

The pressurized volume and weight margins are small, but probably sufficient for contingencies since the resupply margin can be used to resupply pressurized equipment and expendables if they are required. The unallocated margin for communications is zero. It is concluded that this configuration has sufficient capacity to perform all Earth-orbit experiments and still provide reasonable margins for experiment contingencies. Part of the unallocated experiment manhours will be used to simulate the 11-day flyby encounter activities with a four-man crew; two such simulations would require 1000 manhours. Simulations will also be made of the flyby re-entry procedures just prior to each crew rotation. This will require a maximum of 280 hours; one work day for four crew men 7 times during the mission. The purpose of these simulations is to determine the adequacy of a four-man crew to perform these activities and the effect of the high level of activity on the men.

TABLE 3.3-5 EXPERIMENT CAPACITY - SELECTED CONFIGURATION

	ALLOCATED		UNALLOCATED MARGIN	
	PRESS.	UNPRESS.	PRESS.	UNPRESS.
VOLUME (FT^3)	4,079	≈7,500	371	≈ 3,735
WEIGHT (LB) - INITIAL LAUNCH & MANNING	56,460		6,906	
EXPERIMENT MANHOURS - 1st YEAR	17,593		5,152	
ELECTRICAL POWER (KW)	1.0		2.4	
COOLING CAPACITY (KW)	1.0		2.4	
COMMUNICATION RATE (BITS/DAY)	1.26×10^{10}		0	
RESUPPLY WEIGHT (LB/90 DAYS)	1,000		3,350	
PHYSICAL DATA RETURN (LB/90 DAYS)	1,130		NOT EVALUATED	

FOLDOUT FRAME

4.0 VALUE OF COMBINED MISSION TO FLYBY MISSION

The value of the combined mission to the flyby mission is dependent on the environments for the two missions and the similarity of the two configurations. An analysis of the two configurations and a comparison of the environments led to the conclusion that the combined mission has considerable value for the flyby mission.

4.1 SIMILARITY OF THE CONFIGURATIONS

The configurations are very similar except with respect to their experiment packages. The subsystems for the combined mission are identical to the flyby mission except for electrical power and the communications and data management.

4.1.1 ELECTRICAL POWER

The electrical power subsystem for the combined mission contains two major additions to the flyby subsystem: articulating solar panels and increased battery capacity. Two-axis articulating panels are included to provide efficient Earth orbit use. The battery capability is increased to account for the decreased battery life resulting from the high number of charge/discharge cycles in Earth orbit due to occultation.

4.1.2 COMMUNICATIONS AND DATA MANAGEMENT

The basic flyby communications subsystem is capable of providing sufficient RF capability to support the Earth orbit experiments. The subsystem was modified to provide interphone capability for the two crew modules and additional TV because of the desire to isolate the two modules. In addition, rendezvous radar transponders are provided at each of the three docking ports to accommodate resupply and manning missions.

4.1.3 EXPERIMENTS

Seven major experiment groups are planned for the 1975 flyby mission. These groups were analyzed during the study to identify the equipment that could be used effectively to accomplish Earth orbit objectives. The conclusions resulting from the investigation was that the enroute and encounter experiment equipment could be used effectively to accomplish Earth orbit objectives. In addition, the 40 inch aperture multipurpose telescope could be used effectively but the uncertainty of its design led to it not being included. The probes were not included since they do not contribute to the Earth orbit mission objectives and can be tested on the Mars simulation mission which is planned to follow the combined mission. The equipment installations are different for the combined mission since an effort was made to integrate the flyby equipment with the Earth orbit equipment. The differences in installation will not significantly affect the value of the combined mission.

4.2 ENVIRONMENT DIFFERENCES

Substantial differences exist between the environmental conditions prevailing in Earth orbit from those on the flyby mission as shown in Table 4.2-1. The effect of each major environmental difference on the validity of the combined mission as a preparation for the flyby mission is described briefly in the following sections. These effects are only first look and many alternate methods exist for checkout of flyby equipment and operations. Decisions on the alternatives must be made at the time the flyby design is finalized.

4.2.1 EFFECT OF ENVIRONMENT ON SUBSYSTEMS

The environmental differences have no significant effect on the design of the crew, propulsion, guidance and control, and communications and data management subsystems. The EC/LS and electrical power subsystems are affected by the environment. The thermal radiation in Earth orbit is significantly greater than for the flyby mission which decreases the effectiveness of radiators. For this reason the radiator had to be resized to provide the cooling capability required when experiments are being performed. The environment affects the design of the electrical power system because of the occultation that occurs on every orbit. The maximum distance from the spacecraft to the sun allows for the panels to generate considerably more power than is required for the combined mission. The batteries for the flyby mission must be supplemented because of the rate of charge and the number of charge/discharge cycles. The changes required in the design of these subsystems were not major and did not increase the development effort.

The communications and data management subsystem design is not changed due to the differences in environment but the operations are considerably different. The two directional antennas will not be used for normal operations in the combined mission. There is no comparable way to test the link between the spacecraft and the DSIF network. The distance in Earth orbit is too short to do more than check out the link and its proper frequencies.

The flyby mission requires a midcourse maneuver propulsion module (MCPM) with the capability of providing 1200 feet per second velocity when fully loaded with propellant. The combined mission requires a propulsion module capable of providing an orbit circularization velocity of 285 feet per second. The flyby MCPM is used for the combined mission to provide the orbit circularization velocity and is then staged from the space station. Therefore, no tests are made on this module to determine the effect of long term storage in space on the operating characteristics of the engine or the storage of propellant. These effects could be tested by placing a module in orbit for the full two year duration and operating at specific times to simulate the flyby mission.

TABLE 4.2-1 ENVIRONMENT COMPARISON

Environment	Combined Mission	Flyby Mission
Atmosphere Density ~ gm/cm^3		
Surface	$1,225 \times 10^{-6}$	6.82×10^{-6}
150 km	$1,836 \times 10^{-12}$	9.18×10^{-12}
Relative Speed ~ feet/second	25,000	32,000
Altitude Above Surface ~ n.mi.	260	150 - 200
Solar Distance ~ A.U.	1	1 - 2.2
Communications Distance ~ n.mi.	890	2.59×10^8
Planetary Gravity Field ~ cm/sec^2	980	375
Meteroid/Asteroid	Mild	Severe
Thermal Radiation ~ $Watts/Ft^2$		
Sun	125 - 135	46 - 135
Earth	21	0
Penetrating Radiation	75	35
Rads/Year - 10 Lbs/Ft^2 Shield		

The stability and control system operation will be considerably different in Earth orbit than on the flyby mission. The system's capability for the Earth orbital mission is based on providing the station with a 0.1 degree pointing accuracy to the geometric center of the Earth and a stability of 0.05 degrees per second. The vehicle is space oriented for the flyby mission.

The guidance and control system for the flyby mission required some minor modifications to adapt it to the combined mission. The modifications include the addition of a gyro compassing mode of operation, increase in scanner travel, and gain and compensation changes in the electronics. The operation of the guidance and control subsystem will be essentially the same for the two missions.

4.2.2 EFFECT OF ENVIRONMENT ON EXPERIMENTS

The environmental differences will not significantly affect the flyby experiments included for the combined mission. The flyby equipment included in the configuration includes the panoramic camera, enroute and encounter experiments. A one meter telescope is included in the Earth orbital experiment equipment which will be used to test flyby procedures. An analysir of the application of the Earth orbital experiment procedure to the Mars flyby mission is included in Appendix I. This analysis was performed on the flyby probes as well as the equipment contained in the spacecraft.

The telescope is central to the flyby mission since it provides high resolution color photographs of the Mars surface and is used to select locations for deployment of the probes. The atmosphere differences between Earth and Mars have no first order effects on the equipment or operations. The faster angular rotation during the flyby mission can be simulated during the combined mission. All of the flyby procedures can be verified while fulfilling Earth orbit objectives.

The panoramic camera installation will be different for the combined mission but the operations will be the same. The operations required to fulfill the Earth orbit experiment objectives will fully qualify the camera for the flyby mission.

The enroute experiment procedures can be tested on the combined mission but essentially without any contribution to the flyby objectives. Solar physics, communications, meteroid, trapped particle, stellar X-ray, and relativity experiments are included in the enroute experiments. The procedures for performing these experiments can be validated during the combined mission. Additional experiments to be performed are biological experiments on life forms and analyses of Mars samples. The experiments on life forms are extensions of the Earth orbital bioscience experiment objectives. Analyses can be performed on Earth samples to develop the procedures to be used on the Mars samples.

The encounter experiments are essentially identical to the atmospheric sciences and Earth resources experiments for the combined mission. The Earth orbit objectives can be accomplished using the flyby equipment so that the equipment can be qualified and the procedures verified. The experimental data collected using the encounter equipment during the combined mission will not fulfill any of the flyby objectives.

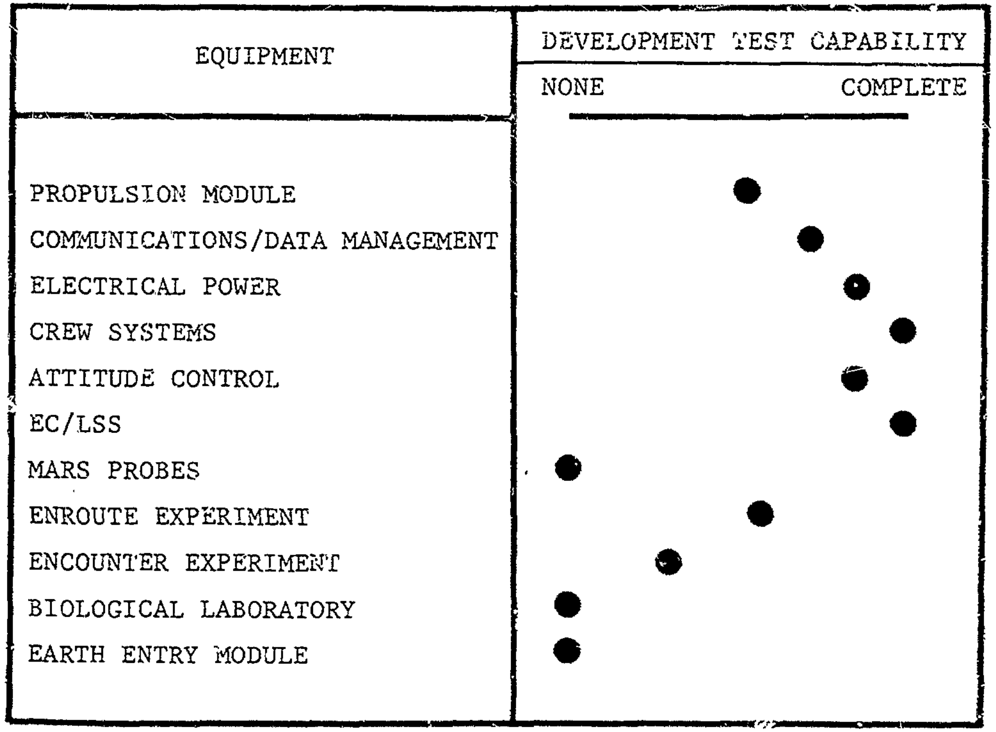
4.3 CONTRIBUTION OF COMBINED MISSION

The combined mission will provide a significant amount of development testing on flyby equipment. All flyby subsystems will be required to operate in nearly the same manner, and for the same duration on the combined mission, as on the flyby mission. Table 4.3-1 shows the development test capability planned for the combined mission. The propulsion module, communications/data management, electrical power, and attitude-control subsystems will be partly tested in Earth orbit. The propulsion module will be used for circularization of the station orbit, and then separated from the station. A partial test is shown, since midcourse correction maneuvers will not be performed and the effects of long durations in space will not be determined. The communications/data management system will operate similarly to the flyby mission except the large directional antennas will not be used and the distances will be much less; therefore, a partial-test is shown. A partial-test is shown for electrical power, since the solar panels will be closer to the Sun and the power generation capability cannot be fully tested. In addition, occultation of the panels changes the operating conditions. The test of the crew systems is considered to be complete. The attitude control can be only partly tested in Earth orbit. The EC/LSS will be completely tested. The Earth entry module (EEM) will not be included in the configuration, so no tests will be performed.

The Mars flyby experiments include equipment which will be tested in Earth orbit. The Mars probes and biological laboratory will not be included in the configuration since they cannot be used to accomplish Earth orbit experiment objectives. The enroute and encounter experiment equipment can be used to accomplish Earth-orbit objectives and, therefore, will be included in the configuration. However, a complete test cannot be performed on the equipment due to differences in installation and operating frequencies; therefore, a partial-test is shown.

The combined mission offers the advantages of 1) early development testing of the flyby hardware in a space environment, 2) opportunity to test alternate designs without jeopardizing crew safety or mission success, 3) simulation of critical periods of the flyby mission, 4) testing postulated crew schedules for long durations, and 5) determination of the physiological effect of the long duration mission on a 4-man crew.

Table 4.3-1: FLYBY EQUIPMENT DEVELOPMENT



5.0 CREW UTILIZATION

The effectiveness of the crew while performing the experiments and station duties was investigated for the selected configuration. The basic schedule for an eight man crew is shown in Figure 5.0-1. This schedule assumes three shifts, two with three men and one with two men. Timeline analyses were then performed using the computer program described in Appendix I, D2-113538-1 to determine the experiment accomplishment.

5.1 CREW SKILLS

The skills for each crewman were selected on the basis of experiment requirements and maintenance tasks. Each crewman is assigned primary skills that are compatible with the requirements of one or more experiment areas. The primary skill and the shift of each crewman is shown in Table 5.1-1. These assignments were made on the basis of a crewman having 2,843 hours per year available to perform experiments. Each experiment area is assigned two or three backup crewmen in the event the primary crewman is unable to complete the experiment program. The primary and backup skills assigned to each crewman indicate the flexibility and training required of crewmen assigned to this mission. Rotation of crewmen to provide new skills at specific intervals of time would be unreasonable since the majority of the experiments span one year. If crews were rotated they would need to be replaced by crewmen with comparable skills.

5.2 EXPERIMENT ACCOMPLISHMENT

The ability of the eight-man crew to accomplish the Earth orbital experiment program as defined in D2-113537-1, "Earth Orbital Station Requirements" was investigated for a 30-day time period using the timeline computer program. The 30-day timeline was performed for the basic schedule of Figure 5.0-1 (10 hours/day) and a 12-hour work day. The 30-day experiment program includes approximately 40 percent more experiment time than is required for 30 days to assure a choice of experiments during the entire period. The basic schedule provides an average of 54.7 hours per week per crewman while the 12-hour work day provides 70 hours per week for experiments. Both schedules are more than sufficient to permit all experiments to be accomplished during the mission. The 10-hour work day schedule of activities is shown in Tables 5.2-1, -2, and -3 for each of the three shifts. The 12-hour work day activity times are different due to the crew being allowed only 30 minutes free time instead of 150 minutes. The 12-hour work day schedule of activities is shown in Tables 5.2-4, -5, and -6 for each of the three shifts.

The experiment input data is shown in Tables 5.2-7, -8, and -9 for the first, second, and third shifts, respectively. These inputs specify which crewmen are capable of performing each of the experiments. The data shown is the same as that for the basic study except for the crew skills.

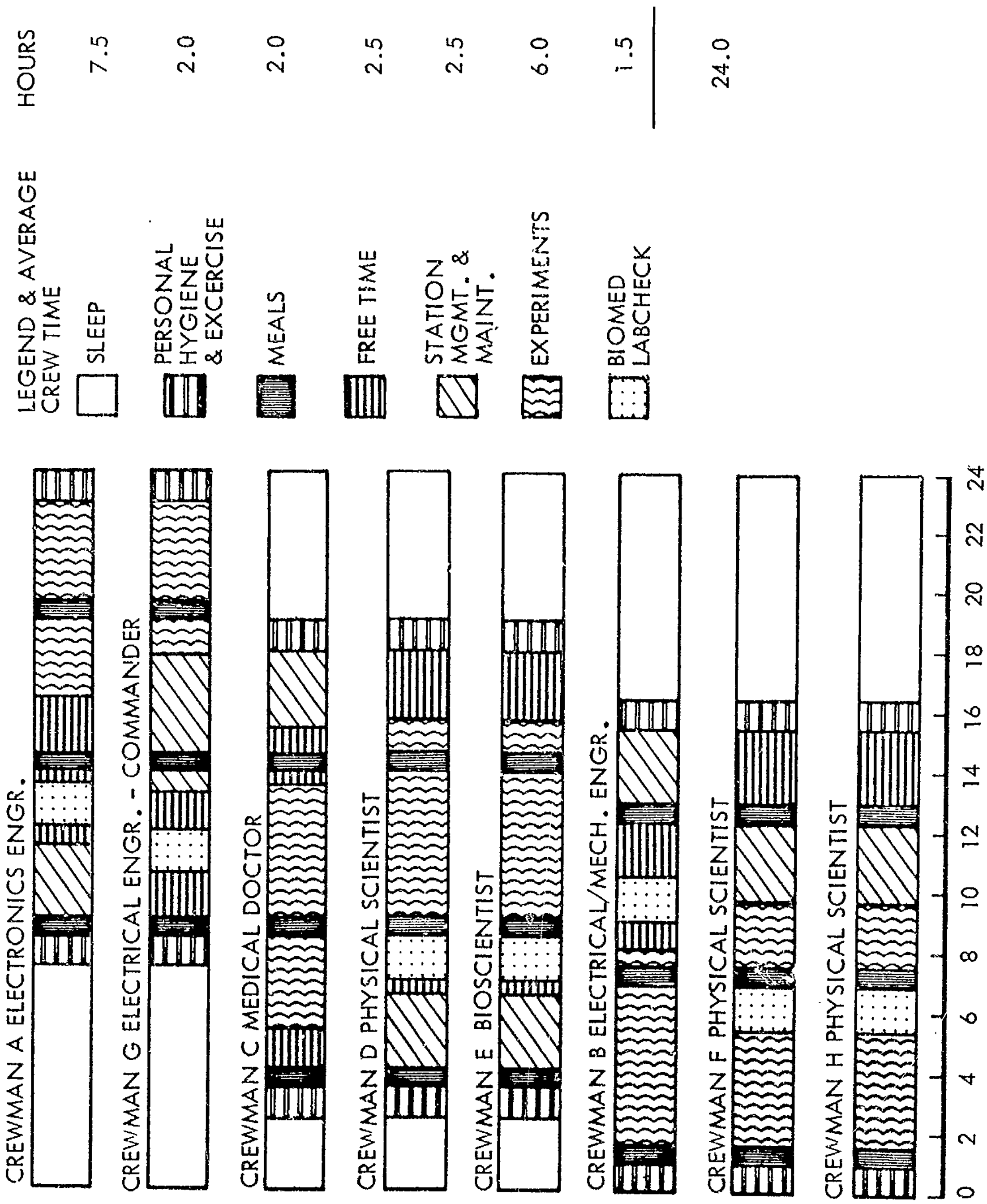


Figure 5.0-1: BASIC CREW SCHEDULE

TABLE 5.1-1: CREW SKILL MIX

EXPERIMENT AREA	CREWMAN PRIMARY	CREWMAN BACKUP	SHIFT
Advanced Technology & Subsystem Devel. Physical Sciences	A. Electronics Engineer Laser/Optical, Controls, Instrumentation, RF & Medical Technician Structure Subsystem	G, F	1
Earth Resources	B. Electrical/Mech. Engr. Photography, Astronomy, Geology, Electrical Power, Structure, & Stabilization & Control Propulsion Subsystem	H,F,A	2
Biomedical	C. Medical Doctor Physiology, Biomedical, Psychology, Bioscience Crew Subsystems	D,E,A	3
Bioscience	D. Physical Scientist Medicine, Biology Communication & Data Mg. EC/LS	C,E,A	3
	E. Bioscientist Ph.D Biology, Biochemical, Physics, & Chemistry, EC/LSS & Crew Subsystems	D,C,A	3
Astronomy	F. Physical Scientist Astronomy, Physics, Geology, & Meteorology	H,B,G	2
Manned Space Operations Communications/Navigation	G. Electrical Engineer-Commander, Navigation, Communications, Controls, Electrical Pwr.& EC/LSS	A, B	1
Atmospheric Sciences	H. Physical Scientist Meteorology, Physics, Optics, Photoprocess., & EC/LSS	B,F,G	2

FOLDOUT FRAME

TABLE 5.2-1: ACTIVITY SCHEDULE (1st SHIFT)

	INITIAL ACTIVITY DATA				
	ACTIVITY TYPE	MINIMUM START TIME	MAXIMUM START TIME	ACTIVITY DURATION TIME	ACTIVITY PERIOD
	**********	*******	*******	********	********
CREW MAN A					
	MIDDAY MEAL	210	270	40	1440
	PERSONAL HYG	430	436	90	1440
	STATION MANG	520	526	240	1440
	EXERCISE	760	766	30	1440
	FREE TIME	790	796	150	1440
	EVENING MEAL	940	946	40	1440
	MAINTENANCE	980	986	60	1440
	LAB CHECKS.	1040	1046	90	1440
	SLEEP	1130	1136	450	1440
	MORNING MEAL	1580	1586	40	1440
CREW MAN B					
	MIDDAY MEAL	210	240	40	1440
	PERSONAL HYG	430	436	90	1440
	STATION MANG	520	526	60	1440
	EXERCISE	580	586	30	1440
	FREE TIME	610	616	150	1440
	EVENING MEAL	760	766	40	1440
	MAINTENANCE	800	806	60	1440
	LAB CHECKS.	950	956	90	1440
	SLEEP	950	956	450	1440
	MORNING MEAL	1400	1406	40	1440

TABLE 5.2-2: ACTIVITY SCHEDULE (2nd SHIFT)

	INITIAL ACTIVITY DATA				
	ACTIVITY TYPE	MINIMUM START TIME	MAXIMUM START TIME	ACTIVITY DURATION TIME	ACTIVITY PERIOD
	**********	*******	*******	********	********
CREW MAN A					
	SLEEP	1	6	450	1440
	MORNING MEAL	451	456	40	1440
	MIDDAY MEAL	761	821	40	1440
	PERSONAL HYG	921	926	90	1440
	STATION MANG	1011	1016	60	1440
	EXERCISE	1071	1076	30	1440
	FREE TIME	1101	1106	150	1440
	EVENING MEAL	1251	1256	40	1440
	AINTENANCE	1291	1296	60	1440
	LAB CHECKS	1351	1356	90	1440
CREW MAN B					
	SLEEP	1	6	450	1440
	MORNING MEAL	451	456	40	1440
	MIDDAY MEAL	761	821	40	1440
	PERSONAL HYG	921	926	90	1440
	STATION MANG	1011	1016	60	1440
	EXERCISE	1071	1076	30	1440
	FREE TIME	1101	1106	150	1440
	EVENING MEAL	1251	1256	40	1440
	AINTENANCE	1291	1296	60	1440
	LAB CHECKS	1351	1356	90	1440
CREW MAN C					
	SLEEP	1	6	450	1440
	MORNING MEAL	451	456	40	1440
	MIDDAY MEAL	761	821	40	1440
	PERSONAL HYG	921	926	90	1440
	STATION MANG	1011	1016	60	1440
	EXERCISE	1071	1076	20	1440
	FREE TIME	1101	1106	150	1440
	EVENING MEAL	1231	1256	40	1440
	AINTENANCE	1291	1296	60	1440
	LAB CHECKS	1351	1356	90	1440

FOLDOUT FRAME

TABLE 5.2-3: ACTIVITY SCHEDULE (3rd SHIFT)

	ACTIVITY TYPE	MINIMUM START TIME	MAXIMUM START TIME	ACTIVITY DURATION TIME	ACTIVITY PERIOD
		INITIAL ACTIVITY DATA			
	**********	*******	*******	*******	********
CREW MAN A					
	PERSONAL HYG	1	6	90	1440
	STATION MANG	91	96	60	1440
	EXERCISE	151	156	30	1440
	FREE TIME	181	186	150	1440
	EVENING MEAL	331	336	40	1440
	MAINTENANCE	371	376	60	1440
	LAB CHECKS	431	431	90	1440
	SLEEP	521	526	450	1440
	MORNING MEAL	971	976	40	1440
	MIDDAY MEAL	1221	1281	40	1440
CREW MAN B					
	PERSONAL HYG	1	6	90	1440
	STATION MANG	91	96	60	1440
	EXERCISE	151	156	30	1440
	FREE TIME	181	186	150	1440
	EVENING MEAL	331	336	40	1440
	MAINTENANCE	371	376	60	1440
	LAB CHECKS	431	431	90	1440
	SLEEP	521	526	450	1440
	MORNING MEAL	971	976	40	1440
	MIDDAY MEAL	1221	1281	40	1440
CREW MAN C					
	PERSONAL HYG	1	6	90	1440
	STATION MANG	91	96	60	1440
	EXERCISE	151	156	30	1440
	FREE TIME	181	186	150	1440
	EVENING MEAL	331	336	40	1440
	MAINTENANCE	371	376	60	1440
	LAB CHECKS	431	431	90	1440
	SLEEP	521	526	450	1440
	MORNING MEAL	971	976	40	1440
	MIDDAY MEAL	1221	1281	40	1440

TABLE 5.2-4: ACTIVITY SCHEDULE (1st SHIFT)

	ACTIVITY TYPE	MINIMUM START TIME	MAXIMUM START TIME	ACTIVITY DURATION TIME	ACTIVITY PERIOD
		INITIAL ACTIVITY DATA			
	**********	*******	*******	*******	********
CREW MAN A					
	MIDDAY MEAL	210	270	40	1440
	PERSONAL HYG	551	556	90	1440
	STATION MANG	641	646	240	1440
	EXERCISE	881	886	30	1440
	FREE TIME	911	916	30	1440
	EVENING MEAL	940	946	40	1440
	MAINTENANCE	980	986	60	1440
	LAB CHECKS.	1040	1046	90	1440
	SLEEP	1130	1136	450	1440
	MORNING MEAL	1580	1586	40	1440
CREW MAN B					
	MIDDAY MEAL	210	240	40	1440
	PERSONAL HYG	551	556	90	1440
	STATION MANG	640	646	60	1440
	EXERCISE	701	706	30	1440
	FREE TIME	731	736	30	1440
	EVENING MEAL	760	766	40	1440
	MAINTENANCE	800	806	60	1440
	LAB CHECKS.	950	956	90	1440
	SLEEP	950	956	450	1440
	MORNING MEAL	1400	1406	40	1440

TABLE 5.2-5: ACTIVITY SCHEDULE (2nd SHIFT)

	INITIAL ACTIVITY DATA				
	ACTIVITY TYPE	MINIMUM START TIME	MAXIMUM START TIME	ACTIVITY DURATION TIME	ACTIVITY PERIOD
	**********	*******	*******	********	********
CREW MAN A					
	SLEEP	1	6	450	1440
	MORNING MEAL	451	456	40	1440
	MIDDAY MEAL	761	821	40	1440
	PERSONAL HYG	1041	1046	90	1440
	STATION MANG	1131	1136	60	1440
	EXERCISE	1191	1196	30	1440
	FREE TIME	1221	1226	30	1440
	EVENING MEAL	1251	1256	40	1440
	AINTENANCE	1291	1296	60	1440
	LAB CHECKS	1351	1356	90	1440
CREW MAN B					
	SLEEP	1	6	450	1440
	MORNING MEAL	451	456	40	1440
	MIDDAY MEAL	761	821	40	1440
	PERSONAL HYG	1041	1046	90	1440
	STATION MANG	1131	1136	60	1440
	EXERCISE	1191	1196	30	1440
	FREE TIME	1221	1226	30	1440
	EVENING MEAL	1251	1256	40	1440
	AINTENANCE	1291	1296	60	1440
	LAB CHECKS	1351	1356	90	1440
CREW MAN C					
	SLEEP	1	6	450	1440
	MORNING MEAL	451	456	40	1440
	MIDDAY MEAL	761	821	40	1440
	PERSONAL HYG	1041	1046	90	1440
	STATION MANG	1131	1136	60	1440
	EXERCISE	1191	1196	30	1440
	FREE TIME	1221	1226	30	1440
	EVENING MEAL	1251	1256	40	1440
	AINTENANCE	1291	1296	60	1440
	LAB CHECKS	1351	1356	90	1440

TABLE 5.2-6: ACTIVITY SCHEDULE (3rd SHIFT)

	INITIAL ACTIVITY DATA				
	ACTIVITY TYPE	MINIMUM START TIME	MAXIMUM START TIME	ACTIVITY DURATION TIME	ACTIVITY PERIOD
	**********	*******	*******	********	********
CREW MAN A					
	PERSONAL HYG	1	6	90	1440
	STATION MANG	91	96	60	1440
	EXERCISE	151	156	30	1440
	FREE TIME	181	186	30	1440
	EVENING MEAL	211	216	40	1440
	MAINTENANCE	251	256	60	1440
	LAB CHECKS	311	316	90	1440
	SLEEP	401	406	450	1440
	MORNING MEAL	851	856	40	1440
	MIDDAY MEAL	1101	1106	40	1440
CREW MAN B					
	PERSONAL HYG	1	6	90	1440
	STATION MANG	91	96	60	1440
	EXERCISE	151	156	30	1440
	FREE TIME	181	186	30	1440
	EVENING MEAL	211	216	40	1440
	MAINTENANCE	251	256	60	1440
	LAB CHECKS	311	316	90	1440
	SLEEP	401	406	450	1440
	MORNING MEAL	851	856	40	1440
	MIDDAY MEAL	1101	1106	40	1440
CREW MAN C					
	PERSONAL HYG	1	6	90	1440
	STATION MANG	91	96	60	1440
	EXERCISE	151	156	30	1440
	FREE TIME	181	186	30	1440
	EVENING MEAL	211	216	40	1440
	MAINTENANCE	251	256	60	1440
	LAB CHECKS	311	316	90	1440
	SLEEP	401	406	450	1440
	MORNING MEAL	851	856	40	1440
	MIDDAY MEAL	1101	1106	40	1440

TABLE 5.2-7

INITIAL (INPUT) EXPERIMENT DATA

EXP NO.	EQP GRP NO.	NO. EXP REP REQ	FIRST MIN START TIME	MIN TIME BETWN REP	MAX TIME BETWN REP	CREW MAN (MEN) REQ	PRED EXP NO.	PRED EXP REP REQ	TIME REQ FOR EXP	DAY OR NIGHT REQ	PRI TGT GRP NO.	OPT TGT GRP NO.	TIME REQ OVER TGT	SETUP TIME FOR TGT	PRI ADD FAC	PRI MULT FAC	PRI FCN NO.	EQUIPMENT OPERATING POWER (W)	ATTITUDE STAB PROP (LB)	STORAGE FOR DATA
P1	1	30	1	1000	0	B			20						-0	-0	1	5.0	.0000	0
P2	2	30	1	1000	0	B			20						-0	-0	1	5.0	.0000	0
P3	3	30	1	1000	0	B			20						-0	-0	1	10.0	.0000	0
P4	4	30	1	1000	0	B			20						-0	-0	1	.0	.0000	0
P5	5	30	1	1000	0	B			20						-0	-0	1	100.0	.0000	0
P6	6	30	1	1000	0	B			20						-0	-0	1	20.0	.0000	2600
P7	7	30	1	1000	0	B			20						-0	-0	1	5.0	.0000	21000
P8	8	30	1	1000	0	[illegible]			20						-0	-0	1	10.0	.0000	21000
P9	9	1	1	90	0	B			11	NIGHT					-0	-0	1	10.0	.0000	0
P10	10	4	1	1440	0	B			240						-0	-0	1	20.0	.0000	29700
P11	11	1	1	43200	0	B			166	DAY					-0	-0	1	90.0	.0000	16188
P12	12	4	1	86400	0	B			120						-0	-0	1	200.0	.0000	5000
P13	13	10	1	0	0	B			167						-0	-0	1	30.0	.0000	0
P14	14	10	1	43200	0	B			180	DAY					-0	-0	1	.0	.0000	0
P15	15	1	1	43200	0	B			167	NIGHT					-0	-0	1	20.0	.0000	0
P16	16	1	1	0	0	B			17						-0	-0	1	20.0	.0000	0
P17	17	1	1	0	0	B			167						-0	-0	1	20.0	.0000	0
P18	18	1	1	0	0	B			167						-0	-0	1	50.0	.0000	0
P19	19	1	1	0	0	B			167						-0	-0	1	100.0	.0000	0
P20	20	2	1	0	0	B			17						-0	-0	1	20.0	.0000	0
P21	21	1	1	0	0	B			17						-0	-0	1	5.0	.0000	0
P22	22	4	1	9000	0	B			60						-0	-0	1	40.0	.0000	2000
C/N1	23	1	1	0	0	A / B	ATS6	1	30						-0	-0	1	.0	.0000	0
C/N2	24	1	1	10080	0	A / B	ATS6	1	17						-0	-0	1	600.0	.0000	560
C/N3	25	1	1	0	0	A / B	ATS6	1	30						-0	-0	1	.0	.0000	0
C/N4	26	1	1	1440	0	A / B	C/N1	1	17						-0	-0	1	600.0	.0000	560
C/N5	27	8	1	1440	0	A / B			17		5	-0	5.0	-0	-0	-0	1	10.0	.0000	80
C/N6	28	8	1	1440	0	A / B			17		5	-0	5.0	-0	-0	-0	1	60.0	.0000	240
C/N7	29	8	1	1440	0	A / B			17		5	-0	5.0	-0	-0	-0	1	2000.0	.0000	8
C/N8	30	8	1	1440	0	A / B			17						-0	-0	1	200.0	.0000	16000
C/N9	31	8	1	0	0	A / B			17						-0	-0	1	50.0	.0000	480
C/N10	32	8	1	90	0	A / B			12		5	-0	2.0	-0	-0	-0	1	5000.0	.0000	16
C/N11	33	8	1	90	0	A / B			40		5	-0	5.0	-0	-0	-0	1	500.0	.0000	950
C/N12	34	2	1	1440	0	A / B	C/N11	1	35		5	-0	5.0	-0	-0	-0	1	500.0	.0000	960
C/N13	35	2	1	1440	0	A / B	C/N12	1	35		5	-0	5.0	-0	-0	-0	1	500.0	.0000	960
C/N14	36	8	1	0	0	A / B	C/N12	1	35		5	-0	5.0	-0	-0	-0	1	500.0	.0000	1920
C/N15	37	8	1	0	0	A / B	C/N12	1	35		5	-0	5.0	-0	-0	-0	1	500.0	.0000	1920
C/N17	38	1	1	0	0	A + B			166						-0	-0	1	1000.0	.0000	30000
C/N19	39	83	1	0	0	A / B			17		5	-0	5.0	-0	-0	2	4	300.0	.0000	20
C/N20	40	8	1	450	0	A / B			17		5	-0	5.0	-0	-0	-0	1	36.0	.0000	10
C/N21	41	8	1	0	0	A / B			17						-0	-0	1	100.0	.0000	0
ATS1	42	1	1	10080	0	A / B			77						-0	-0	1	200.0	.0000	0
ATS2	43	1	1	0	0	A / B			30						-0	-0	1	10.0	.0000	0
ATS3	44	4	1	10080	0	A / B			180						-0	-0	1	10.0	.0000	4000
ATS4	45	1	1	0	0	A + B	MS3	1	2						-0	-0	1	.0	.0000	0
ATS6	45	1	1	1440	0	A + B	MS3	1	240						-0	-0	1	.0	.0000	0
ATS7	47	1	1	0	0	A + B			17						-0	-0	1	50.0	.0000	100
ATS8	48	1	1	10080	0	A + B			17						-0	-0	1	1000.0	.0000	0
ATS9	49	1	1	0	0	A / B			17						-0	-0	1	.0	.0000	0
ATS11	50	8	1	0	0	A / B			17						-0	-0	1	.0	.0000	10

FOLDOUT FRAME

TABLE 5.2-8

INITIAL (INPUT) EXPERIMENT DATA

EXP NO.	EOP GRP NC.	NO. EXP REP REQ	FIRST WIN START TIME	MIN TIME BETWN REP	MAX TIME BETWN REP	CREW MAN (MEN) REQ	PRED EXP NO.	PRED EXP REP REQ	TIME REQ FOR EXP	DAY OR NIGHT REQ	PRI TGT GRP NO.	OPT TGT GRP NO.	TIME REQ OVER TGT	SETUP TIME FOR TGT	PRI ADD FAC	PRI MULT FAC	PRI FCN NO.	EQUIPMENT OPERATING POWER (W)	ATTITUDE STAB PROP (LB)	STORAGE FOR DATA
*****	***	***	******	*****	*****	*****	*****	****	*********	***	***	*****	*****	*****	*****	***	********.*	****.****	**********	
AA1	1	50	1	40	0	ANY 1			40						-0	-0	1	302.0	.0000	0
AA2	2	12	1	40	0	ANY 1			60						-0	-0	1	35.0	.0000	1600
AA3	3	3	1	40	0	ANY 1			105						-0	-0	1	495.0	.0000	0
AA4	4	2	1	40	0	ANY 1	AA2	12	70						-0	-0	1	470.0	.0000	0
AA5	5	3	1	40	0	ANY 1			70						-0	-0	1	500.0	.0000	0
AA6	6	2	1	40	0	ANY 1			40						-0	-0	1	470.0	.0000	0
AA7	7	6	1	40	0	ANY 1			50						-0	-0	1	462.0	.0000	0
AA8	8	30	1	40	0	ANY 1			40						-0	-0	1	35.0	.0000	1600
AA9	9	31	1	40	0	ANY 1			30						-0	-0	1	302.0	.0000	0
AA10	10	31	1	40	0	ANY 1			30						-0	-0	1	302.0	.0000	0
AA11	11	4	1	40	0	ANY 1			40						-0	-0	1	495.0	.0000	0
AA12	12	42	1	40	0	ANY 1			50						-0	-0	1	840.0	.0000	1600
AA13	13	1	1	40	0	ANY 1			40						-0	-0	1	495.0	.0000	0
AA14	14	1	1	40	0	ANY 1			40						-0	-0	1	470.0	.0000	0
AA15	15	104	1	60	0	A / B			30						-0	20	4	500.0	.0000	0
AA16	16	62	1	60	0	A / B			25						-0	20	4	15.0	.0000	0
AA17	17	42	1	60	0	ANY 1			25						-0	20	4	500.0	.0000	0
AA18	18	30	1	40	0	ANY 1			20						-0	-0	1	500.0	.0000	0
AA19	19	83	1	60	0	ANY 1			75						-0	20	4	50.0	.0000	0
AA20	20	42	1	60	0	ANY 1			55						-0	20	4	500.0	.0000	0
AS1	21	17	1	1440	0	A / C			15						-0	-0	1	250.0	.0000	600
AS2	22	8	1	4320	0	A / C	AS1	2	6						-0	-0	1	117.0	.0000	0
AS3	23	67	1	480	0	A / C			15						-0	20	4	250.0	.0000	600
AS4	24	33	1	960	0	A / C			15						-0	20	4	250.0	.0000	600
AS5	25	8	1	4320	0	A / C	AS4	2	25						-0	-0	1	458.0	.0000	60
AS6	26	2	1	90	0	A / C	AS3	3	11						-0	-0	1	337.0	.0000	0
AS7	27	8	1	4320	0	A / C	AS4	4	15						-0	-0	1	250.0	.0000	600
AS8	28	13	1	90	0	A / C	AS1	2	20						-0	-0	1	308.0	.0000	40
AS9	29	13	1	90	0	A / C	AS1	2	10						-0	-0	1	150.0	.0000	20
AS10	30	13	1	2880	0	A / C	AS4	1	10						-0	-0	1	220.0	.0000	600
AS11	31	17	1	1440	0	A / C			15						-0	-0	1	30.0	.0000	0
AS12	32	6	1	5760	0	A / C	AS1	3	25						-0	-0	1	308.0	.0000	40
AS13	33	6	1	5760	0	A / C	AS1	3	10						-0	-0	1	150.0	.0000	20
AS14	34	12	1	90	0	A / C	AS1	1	10						-0	-0	1	220.0	.0000	600
AS15	35	8	1	90	0	A / C	AS1	2	10						-0	-0	1	100.0	.0000	0
AS16	36	17	1	90	0	A / C	AS4	2	15						-0	-0	1	30.0	.0000	0
AS17	37	8	1	4320	0	A / C			30						-0	-0	1	20.0	.0000	0
AS18	38	8	1	4320	0	A / C			11						-0	-0	1	337.0	.0000	0
AS19	39	50	1	720	0	A / C			25						-0	20	4	308.0	.0000	80
AS20	40	50	1	720	0	A / C			27						-0	20	4	285.0	.0000	110
AS21	41	13	1	2880	0	A / C			10						-0	-0	1	150.0	.0000	20
AS22	42	8	1	4320	0	A / C			30						-0	-0	1	20.0	.0000	0
AS23	43	29	1	1440	0	A / C			8						-0	20	4	9.0	.0000	500
AS24	44	29	1	1440	0	A / C			15						-0	20	4	114.0	.0000	0
AS25	45	12	1	2880	0	A / C			10						-0	-0	1	220.0	.0000	600
AS26	46	8	1	2880	0	A / C			11						-0	-0	1	337.0	.0000	0
AS27	47	17	1	1440	0	A / C			20						-0	-0	1	30.0	.0000	20
AS28	48	17	1	1440	0	A / C			20						-0	-0	1	30.0	.0000	20
AS29	49	29	1	1440	0	A / C			30						-0	20	4	373.0	.0000	120
AS30	50	17	1	1440	0	A / C			13						-0	-0	1	9.0	.0000	50

FOLDOUT FRAME

TABLE 5.2-8 (continued)

AS31	51	29	1	1440	0	A	/	C			21	-0	20	4	320.0	.0000	70
AS32	52	4	1	90	0	A	/	C			11	-0	-0	1	337.0	.0000	0
AS33	53	4	1	10080	0	A	/	C			11	-0	-0	1	337.0	.0000	0
ER1	54	8	1	90	0	A	/	C			35	-0	-0	1	576.0	.0000	0
ER2	55	4	1	90	0	A	/	C			20	-0	-0	1	275.0	.0000	300
ER3	56	3	1	90	0	A	/	C			40	-0	-0	1	796.0	.0000	400
ER4	57	3	1	75	0	A	/	C			15	-0	-0	1	1160.0	.0000	3
ER5	58	3	1	90	0	A	/	C			55	-0	-0	1	2246.0	.0000	430
ER6	59	4	1	90	0	A	/	C	ER5	3	12	-0	-0	1	55.0	.0000	1
ER7	60	3	1	90	0	A	/	C			45	-0	-0	1	796.0	.0000	400
ER8	61	5	1	30	0	A	/	C	ER7	3	15	-0	-0	1	1150.0	.0000	1
ER9	62	2	1	90	0	A	/	C	ER7	3	20	-0	-0	1	403.0	.0000	2
ER10	63	3	1	90	0	A	/	C			45	-0	-0	1	876.0	.0000	0
ER11	64	3	1	75	0	A	/	C			15	-0	-0	1	1150.0	.0000	3
ER12	65	8	1	90	0	A	/	C			22	-0	-0	1	378.0	.0000	150
ER13	66	4	1	90	0	A	/	C			70	-0	-0	1	100.0	.0000	3
ER14	67	2	1	90	0	A	/	C			35	-0	-0	1	576.0	.0000	0
ER15	68	6	1	90	0	A	/	C			15	-0	-0	1	300.0	.0000	450
ER16	69	2	1	90	0	A	/	C			55	-0	-0	1	2301.0	.0000	3
ER17	70	12	1	90	0	A	/	C			55	-0	-0	1	2126.0	.0000	10
ER18	71	1	1	90	0	A	/	C			55	-0	-0	1	1948.0	.0000	1
ER19	72	2	1	90	0	A	/	C			55	-0	-0	1	1396.0	.0000	10
ER20	73	2	1	90	0	A	/	C			7	-0	-0	1	20.0	.0000	450
ER21	74	3	1	90	0	A	/	C			55	-0	-0	1	1396.0	.0000	8
ER22	75	1	1	90	0	A	/	C			55	-0	-0	1	650.0	.0000	8
ER23	76	1	1	90	0	A	/	C			55	-0	-0	1	950.0	.0000	2
ER24	77	2	1	90	0	A	/	C			25	-0	-0	1	110.0	.0000	3
ER25	78	2	1	90	0	A	/	C			15	-0	-0	1	1150.0	.0000	0
ER26	79	2	1	90	0	A	/	C			25	-0	-0	1	30.0	.0000	0
ER27	80	2	1	90	0	A	/	C			25	-0	-0	1	220.0	.0000	1500
ER28	81	2	1	90	0	A	/	C	ER17	6	25	-0	-0	1	1670.0	.0000	0
ER29	82	2	1	90	0	A	/	C	ER17	6	20	-0	-0	1	275.0	.0000	410
ER30	83	3	1	90	0	A	/	C			45	-0	-0	1	796.0	.0000	400
ER31	84	2	1	90	0	A	/	C	ER17	6	40	-0	-0	1	1590.0	.0000	0
ER32	85	1	1	90	0	A	/	C	ER17	6	40	-0	-0	1	1790.0	.0000	3
ER33	86	2	1	90	0	A	/	C			12	-0	-0	1	220.0	.0000	150
ER34	87	2	1	90	0	A	/	C			40	-0	-0	1	576.0	.0000	0
ER35	88	2	1	90	0	A	/	C			25	-0	-0	1	300.0	.0000	-0
ER36	89	1	1	75	0	A	/	C			20	-0	-0	1	1250.0	.0000	3
ER37	90	1	1	90	0	A	/	C			15	-0	-0	1	220.0	.0000	150
ER38	91	1	1	90	0	A	/	C			15	-0	-0	1	240.0	.0000	0
ER39	92	2	1	90	0	A	/	C			30	-0	-0	1	2230.0	.0000	450
ER40	93	1	1	90	0	A	/	C			10	-0	-0	1	540.0	.0000	0
ER41	94	2	1	90	0	A	/	C			25	-0	-0	1	730.0	.0000	450
ER42	95	4	1	90	0	A	/	C			20	-0	-0	1	1607.0	.0000	0
ER43	96	7	1	90	0	A	/	C			45	-0	-0	1	1446.0	.0000	460
ER44	97	1	1	90	0	A	/	C			50	-0	-0	1	1343.0	.0000	0
ER45	98	1	1	90	0	A	/	C			30	-0	-0	1	2346.0	.0000	3
ER46	99	1	1	90	0	A	/	C			15	-0	-0	1	275.0	.0000	2
ER47	100	2	1	90	0	A	/	C			30	-0	-0	1	1151.0	.0000	420
ER48	101	2	1	90	0	A	/	C			25	-0	-0	1	575.0	.0000	420
ER49	102	1	1	75	0	A	/	C			20	-0	-0	1	1487.0	.0000	0
ER50	103	1	1	90	0	A	/	C			10	-0	-0	1	100.0	.0000	1000

ADD—ADDITION
ATT—ATTITUDE

EQP—EQUIPMENT
EXP—EXPERIMENT

MIN—MINIMUM
MULT—MULTIPLICATION

PREC—PRECLUSION
PRED—PREDECESSOR

REQ—REQUIRED
STOR—STORAGE

TABLE 5.2-9

INITIAL (INPUT) EXPERIMENT DATA

EXP NO.	EQP GRP NO.	NO. EXP REP REQ	FIRST MIN START TIME	MIN TIME BETWN REP	MAX TIME BETWN REP	CREW MAN (MEN) REQ	PRED EXP NO.	PRED EXP REP REQ	TIME REQ FOR EXP	DAY OR NIGHT REQ	PRI TGT GRP NO.	OPT TGT GRP NO.	TIME REQ OVER TGT	SETUP TIME FOR TGT	PRI ADD FAC	PRI MULT FAC	PRI FCN NO.	EQUIPMENT OPERATING POWER (W)	ATTITUDE STAB PROP (LB)	STORAGE FOR DATA
*****	***	***	******	*****	*****	*****	*****	****	*********	***	***	*****	*****	*****	*****	***	********.*	****.****	**********	
BB1	1	303	1	0	0	B / C			20						-0	-0	1	6.0	.0000	0
BB2	2	13	1000	1440	0	B / C			304						-0	-0	1	11.0	.0000	0
BB3	3	13	1000	1800	0	B / C			315						-0	-0	1	10.0	.0000	0
BB4	4	13	2880	3000	0	B / C			230						-0	2	4	79.0	.0000	0
BB5	5	13	1440	1440	0	B / C			220						-0	-0	1	140.0	.0000	0
BB6	6	26	1440	1440	0	B / C			130						-0	2	4	28.0	.0000	0
BB7	7	7	2820	3000	0	B / C			20						-0	-0	1	500.0	.0000	1500
BB8	8	7	2880	30240	0	B / C			95						-0	2	4	30.0	.0000	0
B1	9	3	1	2880	0	A / C			50						-0	-0	1	50.0	.0000	10
B2	10	9	1	1440	0	A / C			60						-0	-0	1	50.0	.0000	10
B3	11	10	1	1440	0	A / C			30						-0	-0	1	15.0	.0000	4
B4	12	29	1	1440	0	A / C			120						-0	2	4	50.0	.0000	20
B5-8	13	6	1	7200	0	A / C			180						-0	-0	1	40.0	.0000	18
B9	14	29	1	1440	0	A / C			240						-0	2	4	70.0	.0000	3
B10	15	10	1	1440	0	A / C			80						-0	-0	1	.0	.0000	8
B11	16	10	1	1440	0	A / C			60						-0	-0	1	10.0	.0000	6
B12	17	7	1	7200	0	A / C			190						-0	2	4	50.0	.0000	30
B13	18	2	1	7200	0	A / C			20						-0	-0	1	.0	.0000	4
B14	19	10	1	1440	0	A / C			60						-0	-0	1	10.0	.0000	6
B15	20	10	1	1440	0	A / C	B11	5	60						-0	-0	1	10.0	.0000	6
B16	21	1	1	21600	0	A / C			15						-0	-0	1	.0	.0000	2
B17	22	10	1	1440	0	A / C			30						-0	-0	1	40.0	.0000	5
B18	23	2	1	1440	0	A / C			120						-0	-0	1	.0	.0000	6
B19	24	2	1	1440	0	A / C			30						-0	-0	1	50.0	.0000	4
B20	25	1	1	1440	0	A / C			120						-0	-0	1	100.0	.0000	12
B21	26	1	1	1440	0	A / C			50						-0	-0	1	100.0	.0000	5

ADD-ADDITION
ATT-ATTITUDE
BETWN-BETWEEN
CI-CUBIC INCHES
CON-CONTROL

EQP-EQUIPMENT
EXP-EXPERIMENT
FAC-FACTOR
FN-FUNCTION
MAX-MAXIMUM

MIN-MINIMUM
MULT-MULTIPLICATION
OPR-OPERATION
OPT-OPTIONAL

PREC-PRECLUSION
PRED-PREDECESSOR
PRI-PRIORITY
PWR-POWER
REP-REPETITIONS

REQ-REQUIRED
STOR-STORAGE
TARG-TARGET
W-WATTS

TABLE 5.2-9 (continued)

ATS12	51	1	1	0	0	A	+	B	MS3	1	120	-0	-0	1	.0	.0000	0
ATS13	52	1	1	10090	0	A	+	B	MS3	1	137	-0	-0	1	100.0	.0000	10
ATS14	53	5	1	10050	0	A	/	B			17	-0	-0	1	100.0	.0000	100
ATS15	54	4	1	0	0	A	/	B			50	-0	-0	1	770.0	.0000	0
ATS16	55	1	1	0	0	A	/	B			120	-0	-0	1	100.0	.0000	700
ATS17	56	8	1	0	0	A	/	B			17	-0	-0	1	100.0	.0000	10
ATS18	57	8	1	1440	0	A	/	B			17	-0	-0	1	.0	.0000	16
ATS19	58	1	1	90	0	A	/	B			17	-0	-0	1	200.0	.0000	0
ATS20	59	5	1	0	0	A	/	B			17	-0	-0	1	.0	.0000	0
ATS21	60	1	1	0	0	A	+	B			240	-0	-0	1	100.0	.0000	0
ATS22	61	2	1	0	0	A	+	B			17	-0	-0	1	.0	.0000	0
ATS23	62	1	1	0	0	A	+	B			17	-0	-0	1	.0	.0000	16
ATS24	63	1	1	0	0	A	/	B			17	-0	-0	1	.0	.0000	0
ATS25	64	1	1	0	0	A	/	B			17	-0	-0	1	1000.0	.0000	0
ATS26	65	83	1	0	0	A	/	B			17	-0	2	4	500.0	.0000	0
ATS27	66	83	1	0	0	A	/	B			17	-0	2	4	500.0	.0000	8
ATS28	67	4	1	8080	0	A	/	B			240	-0	-0	1	.0	.0000	0
ATS29	68	4	1	8080	0	A	/	B			240	-0	-0	1	.0	.0000	0
ATS30	69	1	1120000		0	A	/	B			120	-0	-0	1	.0	.0000	0
ATS31	70	1	1	8080	0	A	/	B			120	-0	-0	1	350.0	.0000	0
MS2	71	1	1	1440	0	A	+	B			240	-0	-0	1	.0	.0000	0
MS3	72	1	1	1440	0	A	+	B			240	-0	20	4	.0	.0000	0
MS4	73	1	1	0	0	A	+	B			180	-0	-0	1	.0	.0000	0
ATS33	74	1	1	0	0	A	+	B			240	-0	-0	1	1000.0	.0000	0
ATS32	75	3	1	0	0	A	+	B	ATS31	1	150	-0	-0	1	350.0	.0000	1000
ATS34	76	3	1	0	0	A	+	B			150	-0	-0	1	.0	.0000	0
MS1	77	1	1	1440	0	A	+	B			240	-0	-0	1	.0	.0000	0

ADD—ADDITION	EQP—EQUIPMENT	MIN—MINIMUM	PREC—PRECLUSION	REQ—REQUIRED
ATT—ATTITUDE	EXP—EXPERIMENT	MULT—MULTIPLICATION	PRED—PREDECESSOR	STOR—STORAGE
BETWN—BETWEEN	FAC—FACTOR		PRI—PRIORITY	TARG—TARGET
CI—CUBIC INCHES	FN—FUNCTION	OPR—OPERATION	PWR—POWER	W—WATTS
CON—CONTROL	MAX—MAXIMUM	OPT—OPTIONAL	REP—REPETITIONS	

FOLDOUT FRAME 2

Summaries of the experiments accomplished during the first, second, and third shifts for the first 30 days of the mission are shown in Tables 5.2-10, -11, and -12. These summaries are based on the 10 hour work day. The tables show that all repetitions were not completed; this is due to the fact that the 30-day program included 40 percent more experiment manhours than are required. Table 5.2-13 shows the manhours required for each experiment category if 1/12 of the one-year program is to be completed, and compares these data to the total time included in the "30-day" program. It shows that 1,447 manhours are required to complete 1/12 of the program and that 2,018 manhours were included in the 30-day program. It is also shown that a summation of all time spent on experiments during the 30-day timeline generated by the computer program was 1,772 manhours. Thus, as was expected, more than 1/12 of the one-year program was completed.

The 12-hour work day provides significantly more completed experiments. Tables 5.2-14, -15, and -16 summarize the experiments accomplished when the crew is scheduled for a 12-hour work day. All but five of the Advanced Technology and Subsystem Development (ATS) experiments are accomplished and all but two of the Communications and Navigation (C/N) experiments are accomplished. Several of the Physical Sciences (P) experiments are still not completed but the percentage of completion is significantly improved. All Astronomy/Astrophysics (AA) experiments are completed and the percentage of the Atmospheric Sciences (AS) experiments completed is significantly improved as shown in Table 5.2-15. The percentage of Biomedical/Behavioral (BB) experiments completed is significantly improved. This is due primarily to the longer time between activities that occur for the 12-hour work day. BB2 and 3 each require over five hours per repetition. Since the maximum time between activities is three and one-half hours for the 10-hour work day, these experiments will never be scheduled. The 12-hour work day has a maximum time between activities of five hours and five minutes which permits BB2 to be scheduled but not BB3. The remainder of the Biomedical/Behavioral and Bioscience (B) experiments do get scheduled as shown in Table 5.2-16.

The above discussion shows that the duration and repetition rate of experiments must be taken into account. As discussed, long experiments will not be scheduled if other activities are allowed to interfere with their performance. Arrangements must therefore be made in the schedule to relieve crew members for meals and other essential duties or provide monitoring capability. Short experiments which must be repeated one or more times each day are also a problem because they interfere with other experiments. In the timeline program used in this study such experiments were frequently assigned a lower priority (by the program) than other experiments. This resulted in not completing their required repetitions. Such experiments should therefore be examined carefully to verify the need for their high repetition rates. If such rates are required, provisions should be made to accomplish them in parallel with other experiments.

The time spent by each crewman on station duties, activities, and experiments is summarized in Table 2.3-1 (in Section 2.3) for a 10-hour work day. The idle time is the time that the crewmen cannot be scheduled for experiments because of scheduling constraints. A discussion of the scheduling constraints is contained in Appendix I, D2-113538-1, "Earth Orbital Station Utilization." The crew time distribution and idle time for a 12-hour work day is shown in Table 5.2-17. The 12-hour work day results in an average idle time per crewman of two hours per day.

TABLE 5.2-10

SUMMARY (OUTPUT) EXPERIMENT DATA

EXPERIMENT NUMBER	NUMBER REPETITIONS COMPLETED	PERCENT OF REPETITIONS COMPLETED	FINAL PRIORITY VALUE	TIME OF LAST REPETITION
P1	23	76	42	41885
P2	23	76	0	41905
P3	23	76	0	41925
P4	23	76	0	41945
P5	23	76	0	42620
P6	23	76	0	42640
P7	23	76	0	42679
P8	22	73	5384	41218
P9	1	100	0	354
P10	0	0	171560	0
P11	0	0	42890	0
P12	1	25	0	6034
P13	7	70	2604	42023
P14	0	0	428900	0
P15	0	0	42890	0
P16	1	100	0	12417
P17	1	100	0	24748
P18	1	100	0	25181
P19	1	100	0	39138
P20	2	100	0	20355
P21	1	100	0	13327
P22	3	75	641	33250
C/N1	0	0	0	0
C/N2	0	0	0	0
C/N3	0	0	0	0
C/N4	0	0	0	0
C/N5	7	87	2312	39139
C/N6	7	87	2168	39283
C/N7	7	87	203	41246
C/N8	8	100	0	26243
C/N9	8	100	0	21098
C/N10	8	100	0	31100
C/N11	8	100	0	41966
C/N12	2	100	0	20475
C/N13	2	100	0	27543
C/N14	8	100	0	42110
C/N15	8	100	0	42155
C/N17	1	100	0	21868
C/N19	74	89	4122	42662
C/N20	8	100	0	41966
C/N21	8	100	0	23358
ATS1	1	100	0	13300
ATS2	1	100	0	8841
ATS3	1	25	24231	24734
ATS4	0	0	0	0
ATS6	0	0	0	0
ATS7	1	100	0	10499
ATS8	1	100	0	13377
ATS9	1	10[illegible]	0	11741
ATS11	8	100	0	23375
ATS12	0	0	0	0
ATS13	0	0	0	0
ATS14	4	50	0	33421
ATS15	4	100	0	23241
ATS16	1	100	0	16138
ATS17	8	100	0	23426
ATS18	8	100	0	28985
ATS19	1	100	0	11885
ATS20	8	100	0	24677
ATS21	0	0	42890	0
ATS22	8	100	0	26104
ATS23	1	100	0	14601
ATS24	1	100	0	11902
ATS25	1	100	0	11919
ATS26	83	100	0	292[illegible]
ATS27	83	100	0	29215
ATS28	0	0	171560	0
ATS29	0	0	171560	0
ATS30	1	100	0	16154
ATS31	1	100	0	17585
MS2	0	0	42890	0
MS3	0	0	857800	0
MS4	1	100	0	40571
ATS33	0	0	42890	0
ATS32	1	33	10392	37695
ATS34	3	100	0	30507
MS1	0	0	42890	0

TABLE 5.2-11

SUMMARY (OUTPUT) EXPERIMENT DATA

EXPERIMENT NUMBER	NUMBER REPETITIONS COMPLETED	PERCENT OF REPETITIONS COMPLETED	FINAL PRIORITY VALUE	TIME OF LAST REPETITION
AA1	40	80	4570	42580
AA2	12	100	0	40921
AA3	3	100	0	36663
AA4	2	100	0	42341
AA5	3	100	0	33841
AA6	2	100	0	32411
AA7	6	100	0	39521
AA8	29	96	446	42631
AA9	29	93	1012	42571
AA10	29	93	552	42601
AA11	4	100	0	36831
AA12	35	83	3388	42593
AA13	1	100	0	23916
AA14	1	100	0	25131
AA15	104	100	0	38291
AA16	62	100	0	32251
AA17	42	100	0	28026
AA18	30	100	0	41217
AA19	83	100	0	38136
AA20	42	100	0	29391
AS1	13	76	0	42663
AS2	6	75	0	41239
AS3	30	44	285640	42251
AS4	30	90	0	42280
AS5	6	75	0	42366
AS6	2	100	0	30992
AS7	6	75	0	42391
AS8	13	100	0	42446
AS9	13	100	0	41072
AS10	9	69	0	42493
AS11	12	70	0	42295
AS12	4	66	0	39572
AS13	4	66	0	39610
AS14	12	100	0	41052
AS15	8	100	0	38355
AS16	17	100	0	42478
AS17	5	62	1527	38288
AS18	6	75	0	42350
AS19	30	60	56800	42255
AS20	30	60	52400	42266
AS21	9	69	0	42676
AS22	5	62	1437	38318
AS23	25	86	0	42412
AS24	25	86	0	42620
AS25	8	66	0	42490
AS26	7	87	0	42655
AS27	12	70	0	42635
AS28	12	70	0	42643
AS29	24	82	0	42361
AS30	12	70	0	42293
AS31	24	82	0	42391
AS32	[illegible]	100	0	35466
AS33	3	75	[illegible]	39640

ER1	8	100	0	41062
ER2	4	100	0	38268
ER3	3	100	0	36758
ER4	3	100	0	35316
ER5	3	100	0	38088
ER6	4	100	0	42466
ER7	3	100	0	36768
ER8	5	100	0	42420
ER9	2	100	0	39705
ER10	3	100	0	38113
ER11	3	100	0	35451
ER12	8	100	0	41050
ER13	4	100	0	39540
ER14	2	100	0	32435
ER15	6	100	0	39620
ER16	2	100	0	32540
ER17	12	100	0	42435
ER18	1	100	0	25347
ER19	2	100	0	33795
ER20	2	100	0	28273
ER21	3	100	0	38143
ER22	1	100	0	26621
ER23	1	100	0	26632
ER24	2	100	0	32576
ER25	2	100	0	32549
ER26	2	100	0	33873
ER27	2	100	0	33898
ER28	2	100	0	35419
ER29	2	100	0	35431
ER30	3	100	0	38158
ER31	2	100	0	36718
ER32	1	100	0	28202
ER33	2	100	0	32564
ER34	2	100	0	33996
ER35	2	100	0	34016
ER36	1	100	0	23943
ER37	1	100	0	23951
ER38	1	100	0	25359
ER39	2	100	0	35186
ER40	1	100	0	22515
ER41	2	100	0	35203
ER42	4	100	0	38288
ER43	7	100	0	40995
ER44	1	[illegible]	0	26778
ER45	1	100	0	25374
ER46	1	100	0	26706
ER47	2	100	0	35228
ER48	2	100	0	35216
ER49	1	100	0	28203
ER50	1	100	0	26836

TABLE 5.2-12

SUMMARY (OUTPUT) EXPERIMENT DATA

EXPERIMENT NUMBER	NUMBER REPETITIONS COMPLETED	PERCENT OF REPETITIONS COMPLETED	FINAL PRIORITY VALUE	TIME OF LAST REPETITION
BB1	303	100	0	27211
BB2	0	0	548366	0
BB3	0	0	548366	0
BB4	10	76	0	42771
BB5	13	100	0	34131
BB6	25	96	0	43051
BB7	7	100	0	25781
BB8	2	28	0	34391
B1	3	100	0	9831
B2	9	100	0	20041
B3	10	100	0	19791
B4	26	89	0	43051
B5-8	5	83	0	39891
B9	22	75	0	42771
B10	10	100	0	21501
B11	10	100	0	22801
B12	5	71	0	38451
B13	2	100	0	9991
B14	10	100	0	22891
B15	10	100	0	28651
B16	1	100	0	1421
B17	10	100	0	20101
B18	2	100	0	8271
B19	2	100	0	5611
B20	1	100	0	5601
B21	1	100	0	2831

Table 5.2-14:

SUMMARY (OUTPUT) EXPERIMENT DATA

EXPERIMENT NUMBER	NUMBER REPETITIONS COMPLETED	PERCENT OF REPETITIONS COMPLETED	FINAL PRIORITY VALUE	TIME OF LAST REPETITION
P1	25	83	35	41885
P2	25	83	0	41905
P3	25	83	0	41925
P4	25	83	0	41945
P5	25	83	0	41965
P6	25	83	0	42192
P7	25	83	0	42251
P8	25	83	0	42271
P9	1	100	0	865
P10	3	75	6642	34810
P11	1	100	0	16111
P12	1	25	0	4750
P13	8	80	4642	40571
P14	1	10	0	3182
P15	1	100	0	24753
P16	1	100	0	12031
P17	1	100	5	20430
P18	1	100	0	42025

Table 5.2-14: (Cont.)

P19	0	0	42891	0
P20	2	100	0	[illegible]
P21	1	100	0	[illegible]
P22	3	75	642	[illegible]
C/N1	1	100	0	[illegible]
C/N2	1	100	0	[illegible]
C/N3	1	100	0	[illegible]
C/N4	1	100	0	[illegible]
C/N5	8	100	0	[illegible]
C/N6	8	100	0	[illegible]
C/N7	7	87	2063	[illegible]
C/N8	8	100	0	[illegible]
C/N9	8	100	0	[illegible]
C/N10	8	100	0	[illegible]
C/N11	8	100	0	[illegible]
C/N12	2	100	0	[illegible]
C/N13	2	100	0	[illegible]
C/N14	8	100	0	[illegible]
C/N15	8	100	0	[illegible]
C/N17	1	100	0	[illegible]
C/N19	79	95	1840	[illegible]
C/N20	8	100	0	[illegible]
C/N21	8	100	0	20681
ATS1	1	100	0	11931
ATS2	1	100	0	9109
ATS3	3	75	0	40570
ATS4	1	100	0	3060
ATS6	1	100	0	27623
ATS7	1	100	0	10562
ATS8	1	100	0	12048
ATS9	1	100	0	8946
ATS11	8	100	0	[illegible]
ATS12	1	100	0	[illegible]
ATS13	1	100	0	[illegible]
ATS14	4	50	0	[illegible]
ATS15	4	100	0	[illegible]
ATS16	1	100	0	[illegible]
ATS17	8	100	0	[illegible]
ATS18	8	100	0	[illegible]
ATS19	1	100	0	[illegible]
ATS20	8	100	0	[illegible]
ATS21	1	100	0	[illegible]
ATS22	8	100	0	[illegible]
ATS23	1	100	0	[illegible]
ATS24	1	100	0	10615
ATS25	1	100	0	11870
ATS26	83	100	0	26387
ATS27	83	100	0	26404
ATS28	3	75	0	34857
ATS29	3	75	0	42046
ATS30	1	100	0	34758
ATS31	1	100	0	16118
MS2	1	100	0	31940
MS3	1	100	0	1719
MS4	1	100	0	33390
ATS33	1	100	0	37695
ATS32	2	66	6603	36289
ATS34	3	100	0	29190
MS1	1	100	0	39138

TABLE 5.2-13 CREW TIME INPUT FOR 30-DAY TIMELINES

EXPERIMENT CATEGORY	MANHOURS TOTAL 1-YEAR REQUIREMENT	1/12 OF 1-YEAR REQUIREMENT	INCLUDED FOR 30-DAY TIMELINE
ASTRONOMY/ ASTROPHYSICS	4,374	365	400
EARTH RESOURCES	870	73	73
ATMOSPHERIC SCIENCES	2,049	171	158
PHYSICAL SCIENCE	720	60	180
ADVANCED TECH. & SUBSYSTEMS	1,534	128	109
MANNED SPACE OPERATIONS & LOGISTICS	215	18	15
COMMUNICATIONS/ NAVIGATION	518	43	61
BIOMEDICAL/ BEHAVIORAL	4,008	334	734
BIOSCIENCE	3,055	255	288
TOTAL	17,343	1,447	2,018

TOTAL MANHOURS SPENT ON EXPERIMENTS DURING FIRST 30 DAYS (PER TIMELINE) = 1,772 MANHOURS.

Table 5.2-15:

SUMMARY (OUTPUT) EXPERIMENT DATA

EXPERIMENT NUMBER	NUMBER REPETITIONS COMPLETED	PERCENT OF REPETITIONS COMPLETED	FINAL PRIORITY VALUE	TIME OF LAST REPETITION
AA1	50	100	0	33611
AA2	12	100	0	29515
AA3	3	100	0	26582
AA4	2	100	0	30836
AA5	3	100	0	24011
AA6	2	100	0	22601
AA7	6	100	0	28026
AA8	30	100	0	32423
AA9	31	100	0	32351
AA10	31	100	0	32511
AA11	4	100	0	26686
AA12	42	100	0	32629
AA13	1	100	0	18044
AA14	1	100	0	18050
AA15	104	100	0	29336
AA16	62	100	0	23617
AA17	42	100	0	19421
AA18	30	100	0	32260
AA19	83	100	0	27894
AA20	42	100	0	20846
AS1	17	100	0	41013
AS2	8	100	0	42392
AS3	53	79	0	42756
AS4	30	90	0	42278
AS5	7	87	0	39713
AS6	2	100	0	22634
AS7	7	87	0	40976
AS8	13	100	0	31182
AS9	13	100	0	30909
AS10	11	84	0	41207
AS11	17	100	0	41028
AS12	5	83	0	38328
AS13	5	83	0	38353
AS14	12	100	0	30899
AS15	8	100	0	29710
AS16	17	100	0	31232
AS17	7	87	0	39737
AS18	7	87	0	39738
AS19	30	60	56400	42251
AS20	30	60	56400	42251
AS21	11	84	0	42487
AS22	7	87	0	39749
AS23	28	96	0	42583
AS24	28	96	0	42694
AS25	10	83	0	40933
AS26	8	100	0	36822
AS27	17	100	0	41043
AS28	17	100	0	41061
AS29	28	96	0	42722
AS30	17	100	0	40920
AS31	27	93	0	42291
AS32	4	100	0	28235
AS33	4	100	0	42683

Table 5.2-15: (Cont.)

ER1	8	100	0	29718
ER2	4	100	0	28304
ER3	3	100	0	26639
ER4	3	100	0	25502
ER5	3	100	0	26857
ER6	4	100	0	30905
ER7	3	100	0	26902
ER8	5	100	0	30919
ER9	2	100	0	29498
ER10	3	100	0	28020
ER11	3	100	0	26854
ER12	8	100	0	29688
ER13	4	100	0	28323
ER14	2	100	0	23804
ER15	6	100	0	29483
ER16	2	100	0	23933
ER17	12	100	0	31219
ER18	1	100	0	18179
ER19	2	100	0	25142
ER20	2	100	0	8238
ER21	3	100	0	28021
ER22	1	100	0	18185
ER23	1	100	0	18270
ER24	2	100	0	25149
ER25	2	100	0	24063
ER26	2	100	0	25174
ER27	2	100	0	25197
ER28	2	100	0	28169
ER29	2	100	0	28194
ER30	3	100	0	28084
ER31	2	100	0	28214
ER32	1	100	0	22440
ER33	2	100	0	25199
ER34	2	100	0	25222
ER35	2	100	0	25241
ER36	1	100	0	19643
ER37	1	100	0	19663
ER38	1	100	0	19678
ER39	2	100	0	25306
ER40	1	100	0	19693
ER41	2	100	0	25332
ER42	4	100	0	28324
ER43	7	100	0	29520
ER44	1	100	0	19703
ER45	1	100	0	20891
ER46	1	100	0	20918
ER47	2	100	0	25387
ER48	2	100	0	25417
ER49	1	100	0	20921
ER50	1	100	0	19753

Table 5.2-16:

SUMMARY (OUTPUT) EXPERIMENT DATA

EXPERIMENT NUMBER	NUMBER REPETITIONS COMPLETED	PERCENT OF REPETITIONS COMPLETED	FINAL PRIORITY VALUE	TIME OF LAST REPETITION
BB1	303	100	0	20001
BB2	13	100	0	35701
BB3	0	0	547846	0
BB4	10	76	0	42901
BB5	13	100	0	28525
BB6	26	100	0	42901
BB7	7	100	0	25491
BB8	2	28	0	34015
B1	3	100	0	11245
B2	9	100	0	18601
B3	10	100	0	16911
B4	27	93	0	42655
B5-8	6	100	0	41211
B9	24	82	0	42901
B10	10	100	0	19671
B11	10	100	0	16661
B12	6	85	0	38331
B13	2	100	0	8611
B14	10	100	0	19631
B15	10	100	0	24055
B16	1	100	0	1421
B17	10	100	0	17251
B18	2	100	0	5461
B19	2	100	0	3931
B20	1	100	0	5211
B21	1	100	0	3881

TABLE 5.2-17: CREW EXPERIMENT ASSIGNMENTS SUMMARY
(30 Day Time Line; 30 Minutes/Day Free Time)

ACTIVITY OR EXPERIMENT AREA	CREW TIME ASSIGNMENT Percent							
	A	B	C	D	E	F	G	H
ACTIVITIES								
Sleep	31	31	31	31	31	31	31	31
Exercise & Free Time	4	4	4	4	4	4	4	4
Personal Hygiene & Meals	15	15	15	15	15	15	15	15
Station Management and Maintenance	8	8	8	8	8	8	8	8
EXPERIMENT AREA								
Biomedical/Behavioral	6	6	31	25	6	6	6	6
Bioscience				7	30			
Astronomy/Astrophysics		12				27		16
Earth Resources		6						4
Atmospheric Sciences		9						14
Physical Sciences	17							
Advanced Technology	5						15	
Communications/Navigation	9						4	
Manned Space Operations	2						2	
Idle Time	3	9	11	10	6	9	15	2
TOTAL	100	100	100	100	100	100	100	100

6.0 RELIABILITY AND MAINTENANCE

6.1 SUCCESS CRITERIA

The success criteria used for this study were based on the study ground rules and assumptions regarding mission description which influence reliability, safety and maintainability. A minimum acceptable level of mission success probability (Pms) was established at 0.99 for 730 days to assure a satisfactory level of crew safety. The mission durations which were evaluated were 90, 365, and 730 days. The probability of success applies to only the orbital phase of the mission and does not include boost or re-entry phases of the mission. Proper operation of experiment/equipment is also excluded from the mission success analysis.

With resupply provisions for spares and redundancy, a .99 probability of success can be maintained for the full 730 day duration of the mission providing that a .99875 P_{ms} is assured for each of eight 90 day intervals or .995 P_{ms} is assured for each of two 365 day intervals. At each resupply interval, expendables and spares will be replenished as necessary to restore the spacecraft to its initial P_{ms} for the 90 or 365 day interval.

6.2 RELIABILITY, MAINTAINABILITY ANALYSIS

6.2.1 APPROACH

The purpose of the reliability/maintainability analysis was to derive the requirements for achieving numerical reliability and safety goals. Based on the results of previous studies, a certain amount of crew participation for maintenance/restoration activities are assumed as a requirement to achieve satisfactory mission success goals. By providing for crew maintenance activities, the additional weight required for redundancy can be reduced significantly even with planning for a minimum maintenance program. The approach to the reliability/maintainability analysis was to derive an estimate of requirements for:

- weight of spares and redundancy;
- maintenance time.

The analysis method employed was the Maintainability and Reliability Cost Effectiveness Program (MARCEP) whereby redundancy and spare alternatives are selected to supplement the single thread system on the basis of best gain in reliability or safety for the least expenditure of critical resource (weight, cost, volume, etc.). The MARCEP analysis method is discussed in more detail in the following section.

6.2.2 MARCEP ANALYSIS

6.2.2.1 METHODOLOGY

The reliability/maintainability analysis was performed with a computer programmed mathematical model called MARCEP which was used extensively in support of work conducted by Boeing under Contract NAS2-3705 (Study of Maintainability of Long-Duration Manned Space Flight), completed July 1967.

The subsystem designer defines the subsystem, identifies the actual hardware components to be used, and determines the component level in the subsystem that will be maintained. The designer develops information on the criticality of the component to space station crew safety, establishes allowable subsystem down time, and the difficulty of component repair. Component failure rates are identified by the design and reliability engineers. Initially a nonredundant single-thread system is defined. This is a basic system of components which has the capability of performing all of the required space station functions as long as no component failure occurs. Actually, because of the desire to use existing hardware, some components may already have some form of redundancy built into them. In this case, the component failure rate is established to reflect the probability of failure (including failure of any built-in redundancy) of the function which the component is supposed to perform.

The MARCEP then determines the reliability of each component and the total basic space station reliability for the mission duration being considered. Each item is then considered for addition to the system in one of three ways: parallel redundancy, standby redundancy, and spares redundancy; the possible methods being determined by repairability and criticality codesused to describe the component as part of the basic system. The program uses Fortran IV language which is operated by the Univac 1108 digital computer.

For each component, parametric evaluation and selection of each method of addition are conducted, and the parametric value stored in tabular array. The parametric value stored in this study was change in reliability per added component weight. The change is due to the trial addition of the component to the system. When parametric values have been stored for each component, the entire array is searched to select the largest value. The component responsible for this value is then added to the system per the selected method.

As a component is added to the system, a new parametric value is determined for it, and the new value is entered in the tabular array. Each time a component is added to the system, it is added in the most advantageous form of redundancy possible. This iterative process can proceed indefinitely, but practical or required constraints are applied to terminate the process. A more detailed technical discussion of the MARCEP processes is available in "MARCEP - Maintainability and Reliability Cost Effectiveness Program," E. P. Trott, The Boeing Company, paper presented at Fourth Annual Reliability and Maintainability Conference, Los Angeles, California, July 1965.

The useful result of the program is a printed sheet of the components added to the system, in their sequence of addition, with new system reliability, method of addition, and cumulative system weight shown. A typical computer printout from MARCEP is shown in Appendix II.

6.2.2.2 MARCEP DATA SHEETS

Subsystem MARCEP data sheets were used to organize the subsystem variables into a format which could be punched on computer cards for automated analysis. The subsystem MARCEP data sheets for the flyby mission are included in Appendix II. These data sheets formed the basis for the combined mission also. No new data sheets were prepared for the combined mission. The data point entries made on the MARCEP data sheets are explained in the following paragraphs:

a) Nomenclature

The nomenclature describing each component or assembly provides the first entry on the data sheet. In total, this represents an equipment list for the entire space station.

b) Subsystem

Each subsystem was assigned a two-letter identification code:

Subsystem	Code
Communications and Data Management	CD
Crew System	CS
Electrical Power	EP
In-Flight Test	IF
Life Support and Environmental Control	LS
Maintenance Equipment	ME
Propulsion	PP
Guidance and Control	SC

c) Component Number

Each component within a given subsystem was assigned an arbitrary number, according to the original sequence when the subsystem listing was established. Once this number was assigned it was inviolable, and never reused if the item subsequently was deleted as a result of further analysis and evaluation. Any item added after the original sequence had been established was given the next unassigned number regardless of its place in the sequence.

d) Quantity in Basic System

Reflects the number of units required to make up a basic, essentially nonredundant, but completely operable subsystem.

e) Operating Failure Rate ($x\ 10^7$)

This is the average number of times the component may be expectea to fail in 10,000,000 hours of operation.

f) Dormant Failure Rate ($x\ 10^7$)

This is the average number of times a component may be found to be faulty during 10,000,000 non-operating or on-the-shelf hours.

g) Weight in Pounds

Weight per unit of the line item.

h) Volume in Cubic Centimeters

Volume per unit of the line item.

i) Mean Repair Time

Time in hours adjudged to be the average required to restore the item to its original operating condition after a failure has occurred. A very serious effort was made to be realistic in this fi ure, taking into account the space environment, special conditions if appropriate, kinds of tools and other resources required, and inherent difficulty of the function.

j) Repairability Code

Each item was evaluated for its susceptibility to repair and a code number assigned. This code is introduced into the computer program for determining the relative merits of sparing or making redundant. Codes used were as follows:

1) Item cannot be spared or made redundant.

2) Item cannot be repaired or replaced in orbit.

3) Repair requires external work in spacesuit

4) Repair is difficult, poor access or other factor

5) Repair is easily accomplished, shirtsleeve environment.

k) Criticality Code

Each item also was evaluated for the influence it had on the system in the event of a fault. Codes used were:

1) Safety critical, item must operate continuously.

2) Downtime critical, redundancy required.

3) Downtime critical, repair in maximum downtime or less.

4) Repair can be deferred up to 7 days (except RC-2 or RC-3).

5) Repair can be deferred indefinitely.

6) Spares only.

l) Maximum Allowable Downtime

This was the maximum elapsed time in hours which could be tolerated between a failure and restoration of the system or equipment to an operating condition.

m) First Supplementary Component Number

The entry in this column is a separate computer code number for an additional switch, valve, indicator, sensing or monitoring devices, or other part required when the line item is added in as standby redundant. Weights, volumes, reliabilities, etc., of these units are mitigating factors to be applied when the line item is added as standby redundant.

n) Second Supplementary Component Number

An additional entry to be used as above when a second such component is required. This may or may not be the same as the first component.

o) Percent Operating Time (x 10)

The proportion of a mission during which the line item is anticipated to be working. Multiplying by ten, permits computer mechanization of items with operating times as low as 0.1 percent.

p) Parallel Lockout

Denies consideration of the line item as a parallel redundant unit. Applies particularly to components associated with EVA, experiments, structure, ducts, and other items for which it is not practicable to provide parallel redundancy.

6.2.2.3 MARCEP ANALYSIS RESULTS

The MARCEP analysis was to 0.99 probability of mission success (P_{ms}) for 730 days, or its equivalent for 90 days or 365 days as explained in Paragraph 6.1. Appendix II includes a typical computer subsystem printout for the MARCEP analysis.

Figure 6.2-1 shows the weight added to the space station initial weight to achieve various probabilities of mission success for 90, 365, and 730-day durations. Based on these data, 15,500 pounds of spares and redundancy are required for the initial launch to achieve 0.99 P_{ms} for 730 days for the combined mission. Figure 6.2-2 shows the same data for the four-man flyby mission. For this mission only 12,000 pounds are required to achieve a 0.99 P_{ms} for 730 days. Table 6.2-1 demonstrates the improvement in reliability required by each subsystem in order to realize a 0.99 P_{ms} for 730 days. Because of additional requirements for the combined mission, it will be noted that some of the systems have a lower initial reliability than for the flyby mission, Table 6.2-2. The initial reliability indicates the probability of that subsystem completing the mission without a failure, if

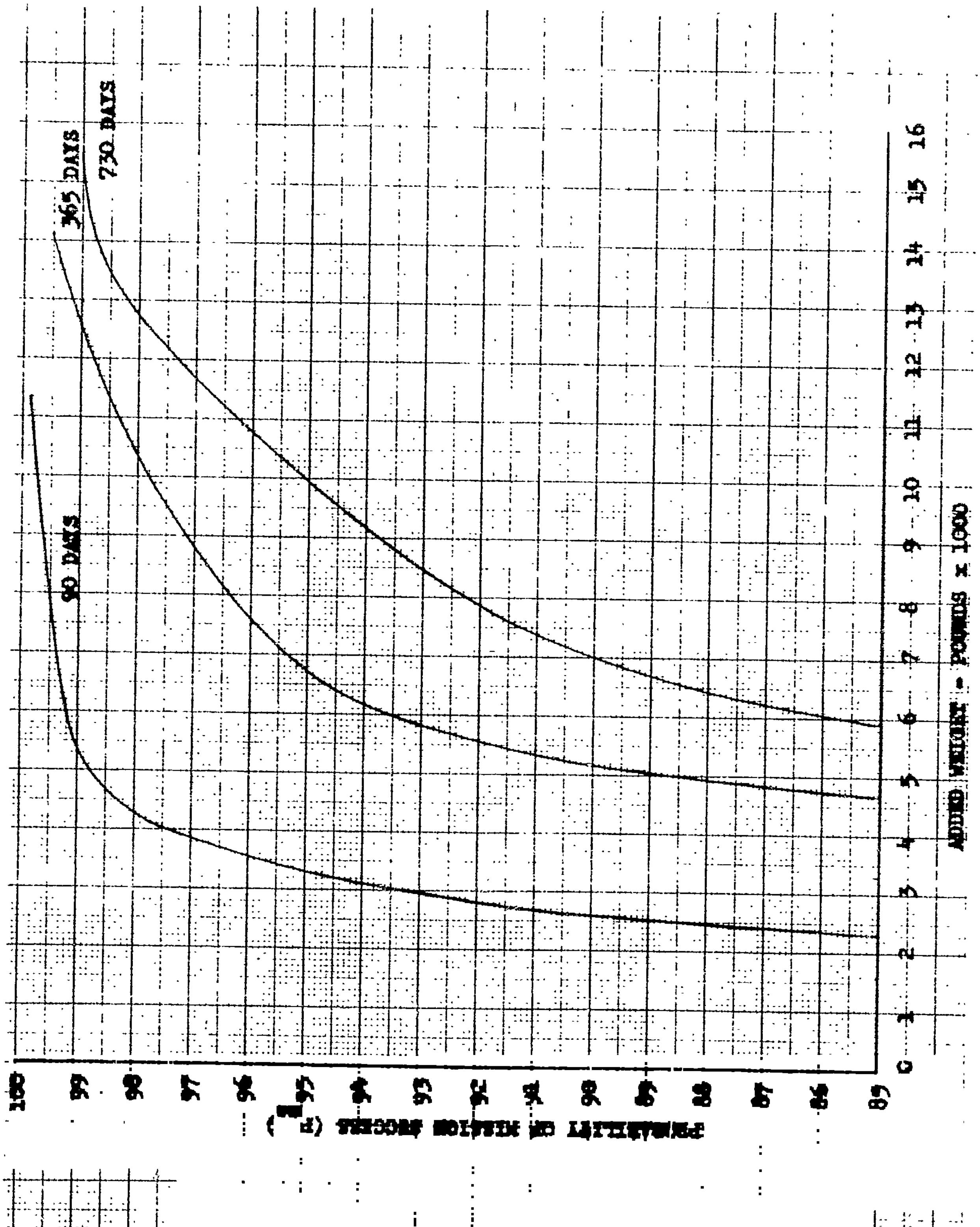


Figure 6.2-1: WEIGHT ADDED FOR RELIABILITY
Combined Mission

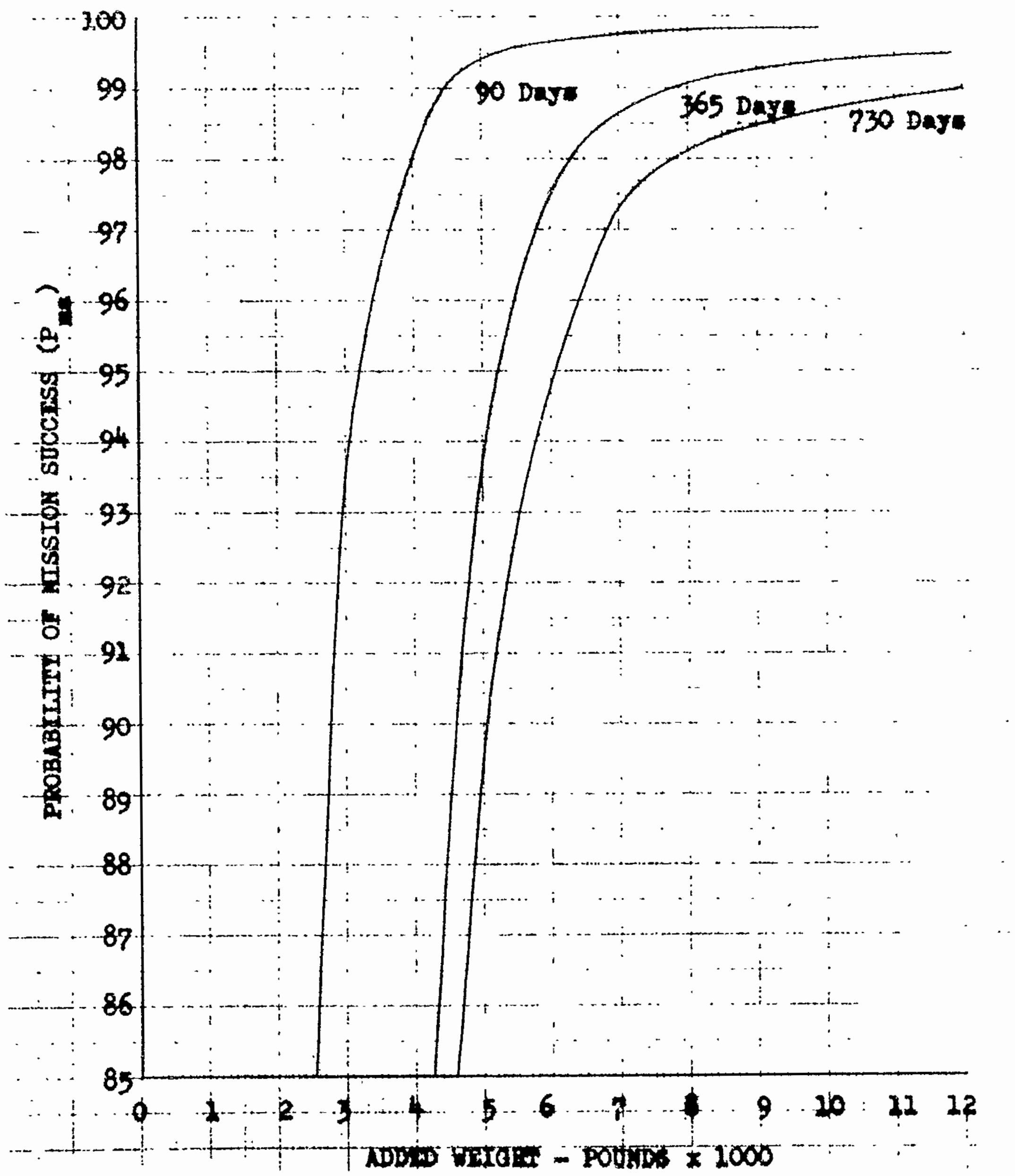


Figure 6.2-2: WEIGHT ADDED FOR RELIABILITY
Flyby Mission

TABLE 6.2-1 - SUBSYSTEM RELIABILITY COMBINED MISSION

SUBSYSTEM	RELIABILITY FOR 730 DAYS INITIAL	FINAL
Communications and Data Management	2.4×10^{-7}	.99931
Crew System	1.1×10^{-5}	.99942
Electrical Power	4.9×10^{-2}	.99839
Inflight Test	1.2×10^{-5}	.99983
EC/LSS	7.7×10^{-11}	.99599
Maintenance Equipment	9.4×10^{-1}	.99996
Propulsion	2.3×10^{-2}	.99812
Guidance and Control	2.5×10^{-4}	.99899
All Subsystems	6.47×10^{-34}	.99004

TABLE 6.2-2 - SUBSYSTEM RELIABILITY FLYBY MISSION

SUBSYSTEM	RELIABILITY FOR 730 DAYS	
	INITIAL	FINAL
Communications and Data Management	4.5×10^{-6}	.99900
Crew System	3.3×10^{-3}	.99936
Electrical Power	7.7×10^{-2}	.99806
Inflight Test	1.2×10^{-5}	.99968
EC/LSS	9.2×10^{-6}	.99850
Maintenance Equipment	0.94	.99996
Propulsion	2.27×10^{-2}	.99706
Guidance and Control	2.46×10^{-4}	.99847
All Subsystems	8.85×10^{-29}	.99014

no redundancy or spares are provided. The final reliability is that attained for each subsystem after redundancies and spares have been added to the spacecraft. Tables 6.2-3, -4, and -5 show the breakdown of spares and redundancy weight added by subsystem compared to its initial or single-thread weight for 90-, 365-, and 730-day combined missions. Comparable data for the basic flyby mission is presented in Figures 6.2-6, -7, and -8.

The following paragraphs discuss the major contributing weight items for each subsystem for the 730-day combined mission.

Detailed discussions of each subsystem are presented in Document D2-114015-1. There will be some differences between the data shown on the MARCEP sheets and that given in the subsystem descriptions. This is because of changes made to the subsystems too late in the study period to be incorporated in the MARCEP computer analysis. This is not considered significant because the differences are minor and the spares trends are the same.

a) Communication and Data Management

Weight added--1409 pounds (150 pounds redundancies, 1259 pounds spares). An initial MARCEP run, utilizing the MARCEP data sheets displayed in Appendix II, revealed that over 3200 pounds of spares and redundant equipment were required for the Communications and Data Management Subsystem. In an effort to explore the impact on weight added, a second run was made in which the high weight and/or high failure rate items were modularized such that remove/replace and other maintenance actions were assumed to be accomplished at a lower level. This was done because it is known that electronic units are usually submodularized. Lacking specific knowledge of the lower level modularization of the Communications and Data Management subsystem components, the items were assumed to be built up from a number of each of three or four basic modules. As an example, the modularization assumed for the U.S.B. transponder was that it consisted of four different modules; there was assumed to be one each of two of the modules, two of a third module, and four of the fourth module. The total transponder failure rate, weight, and volume was divided among the four types of modules. This reduced the spares and redundancy requirements to only 1409 pounds for a weight saving of over 1800 pounds. Since the feasibility of a modular design approach depends on the additional costs incurred through redesign of existing hardware, a cost study is required before the economic advantages of this approach can be assessed. The items which were modularized for the second iteration were:

Data Storage Unit*	Computer*
PCM T/M Unit*	Data Adapter*
Video Tape Recorder	Input Keyboard
TV Monitor	USB Transponder*

S. B. Power Amplifier (1350-w)*

TABLE 6.2-3 - REDUNDANCY AND SPARES ADDITIONS COMBINED MISSION

90 DAYS TO .99875 P_{MS}

SUBSYSTEM	INITIAL WEIGHT (LBS.)	INITIAL VOLUME (FT.^{3})	ADDITIONS REDUNDANCY WEIGHT	ADDITIONS REDUNDANCY VOLUME	ADDITIONS SPARES WEIGHT	ADDITIONS SPARES VOLUME	TOTAL WEIGHT	TOTAL VOLUME
Communications & Data Management	1,559		150	2.3	793	13.7	943	16.0
Crew Systems	19,914		0	0	635	67.4	635	67.4
Electrical Power	11,996		749	25.6	(2) 800	21.8	1,549	47.4
Inflight Test	294		0	0	275	5.6	275	5.6
EC/LSS	41,789		(3) 4,301	180.0	1,477	124.0	5,778	304.0
Maintenance Equip.	62		0	0	41	1.2	41	1.2
Propulsion	10,943		233	10.3	6	0.1	239	10.4
Guidance and Control	4,549		(4) 893	29.6	986	16.1	181	45.7
TOTAL	(1) 91,106		6,326	247.8	5,013	249.9	11,339	497.7

(1) Includes 55,806 lbs of expendables.
(2) Includes one spare battery - 345 lbs.
(3) Includes one each parallel redundant O_2 and N_2 tanks with 1645 lbs O_2 and 1150 lbs N_2, and two parallel redundant fluid reservoirs with 150 lbs E-2 fluid in each.
(4) Includes one each parallel redundant fuel and oxidizer tanks with 200 lbs fuel and 25 lbs oxidizer.

TABLE 6.2-4 - **REDUNDANCY AND SPARES ADDITIONS COMBINED MISSION**

365 DAYS TO .995 P_{MS}

SUBSYSTEM	INITIAL WEIGHT (LBS.)	INITIAL VOLUME (FT.^{3})	REDUNDANCY WEIGHT	REDUNDANCY VOLUME	ADDITIONS SPARES WEIGHT	ADDITIONS SPARES VOLUME	TOTAL WEIGHT	TOTAL VOLUME
Communications and Data Management	1,559		150	2.3	1,080	18.6	1,230	20.9
Crew System	19,914		0	0	752	80.0	752	80.0
Electrical Power	11,996		751	25.6	(2) 1,848	51.8	2,599	77.4
Inflight Test	294		0	0	334	6.7	334	6.7
EC/LSS	41,789		(3) 4,337	180.0	2,309	210.0	6,646	390.0
Maintenance Equip.	62		0	0	41	1.1	41	1.1
Propulsion	10,943		233	10.3	8	0.1	241	10.4
Guidance and Control	4,549		(4) 915	30.6	1,362	27.4	2,277	58.0
TOTAL	91,106		6,386	248.8	7,734	395.7	14,120	644.5

(2) Includes two spare batteries - 690 lbs total
(1), (3), and (4) Same as for 90 day mission time

TABLE 6.2-5 - **REDUNDANCY AND SPARES ADDITIONS COMBINED MISSION**

730 DAYS TO .99 P_{MS}

SUBSYSTEM	INITIAL WEIGHT (LBS.)	INITIAL VOLUME (FT.^{3})	ADDITIONS REDUNDANCY WEIGHT	REDUNDANCY VOLUME	SPARES WEIGHT	SPARES VOLUME	TOTAL WEIGHT	TOTAL VOLUME
Communications and Data Management	1,559		150	2.3	1,259	21.4	-1,409	23.7
Crew System	19,914		0	0	859	86.5	859	86.5
Electrical Power	11,996		755	25.6	(2) 2,215	65.9	2,970	91.5
Inflight Test	294		0	0	373	7.3	373	7.3
EC/LSS	41,789		(3) 4,540	215.0	2,358	177.0	6,898	392.0
Maintenance Equip.	62		0	0	41	1.2	41	1.2
Propulsion	10,943		233	10.3	12	0.2	245	10.5
Guidance and Control	4,549		(4) 945	32.2	1,703	50.1	2,648	82.3
TOTAL	91,106		6,623	285.4	8,820	409.6	15,443	695

(1),(2),(3), and (4) - Same as for 365 day mission time.

TABLE 6.2-6 - REDUNDANCY AND SPARES ADDITIONS FLYBY MISSION

90 DAYS TO .99875 P_{MS}

SUBSYSTEM	INITIAL WEIGHT (LBS.)	INITIAL VOLUME (FT.^{3})	REDUNDANCY WEIGHT	REDUNDANCY VOLUME	ADDITIONS SPARES WEIGHT	ADDITIONS SPARES VOLUME	TOTAL WEIGHT	TOTAL VOLUME
Communications and Data Management	1,334	18.4	150	2.3	689	12.8	848	15.1
Crew System	10,448	1112.0	0	0	555	53.4	555	53.4
Electrical Power	5,550	35.8	364	12.0	(2) 599	14.0	963	26.0
Inflight Test	294	3.3	0	0	264	5.2	264	5.2
EC/LSS	17,982	362.0	(3) 3,649	92.3	761	37.7	4,410	130.0
Maintenance Equip.	62	3.1	0	0	41	1.1	41	1.1
Propulsion	27,380	726.0	50	0.3	6	0.1	56	0.4
Guidance and Control	4,549	98.5	(4) 893	29.6	871	13.8	1,764	43.4
TOTAL	67,599	2,339	5,106	136.5	3,795	138.1	8,901	274.6

(1) Includes 41,800 lbs of fluids.
(2) Includes one spare battery of 345 lbs and 5.1 ft^3
(3) Includes one each parallel redundant O_2 and N_2 tanks with 1645 lbs O_2 and 1150 lbs N_2, and one parallel redundant fluid reservoir with 150 lbs E-3 fluid.
(4) Includes one each parallel redundant fuel and oxidizer tanks with 200 lbs fuel and 425 lbs oxidizer. Each tank weighs 26 lbs.

TABLE 6.2-7 - **REDUNDANCY AND SPARES ADDITIONS FLYBY MISSION**

365 DAYS TO .995 P_{MS}

SUBSYSTEM	INITIAL WEIGHT (LBS.)	INITIAL VOLUME (FT.^{3})	ADDITIONS REDUNDANCY WEIGHT	ADDITIONS REDUNDANCY VOLUME	ADDITIONS SPARES WEIGHT	ADDITIONS SPARES VOLUME	TOTAL WEIGHT	TOTAL VOLUME
Communications and Data Management	1,334	18.4	150	2.3	974	16.4	1,124	18.7
Crew System	10,448	1,112.0	0	0	635	63.2	635	63.2
Electrical Power	5,550	35.8	364	12.0	(2) 1,262	30.5	1,626	42.5
Inflight Test	294	3.3	0	0	310	6.5	310	6.5
EC/LSS	17,982	362.0	(3) 3,651	92.3	1,121	57.3	4,772	149.6
Maintenance Equip.	62	3.1	0	0	41	1.1	41	1.1
Propulsion	27,380	726.0	50	0.3	6	0.1	56	0.4
Guidance and Control	4,549	98.5	(4) 908	30.1	1,273	25.6	2,181	55.7
TOTAL	(1) 67,599	2,339	5,123	137.0	5,622	200.7	10,745	337.7

(1) Includes 41,800 lbs of fluids
(2) Includes two spare batteries with total weight of 690 lbs.
(3) and (4) See Table 6.2-6.

TABLE 6.2-8 - **REDUNDANCY AND SPARES ADDITIONS FLYBY MISSION**
730 DAY TO .99 P_{MS}

SUBSYSTEM	INITIAL WEIGHT (LBS.)	INITIAL VOLUME (FT.^{3})	ADDITIONS REDUNDANCY WEIGHT	ADDITIONS REDUNDANCY VOLUME	ADDITIONS SPARES WEIGHT	ADDITIONS SPARES VOLUME	TOTAL WEIGHT	TOTAL VOLUME
Communications and Data Management	1,334	18.4	150	2.3	1,169	20.2	1,319	22.5
Crew System	10,448	1,112.0	0	0	673	64.6	673	64.6
Electrical Power	5,550	35.8	367	12.0	(2) 1,484	38.3	1,851	50.3
Inflight Test	294	3.3	0	0	362	7.1	362	7.1
EC/LSS	17,982	362.0	(3) 3,651	92.3	1,411	73.0	5,062	165.3
Maintenance Equip.	62	3.1	0	0	41	1.1	41	1.1
Propulsion	27,380	726.0	58	0.4	11	0.2	69	0.6
Guidance and Control	4,549	98.5	945	31.8	1,611	36.5	2,566	68.3
TOTAL	(1) 67,599	2,339	5,171	138.8	6,762	241.0	11,933	379.8

(1) Includes 41,800 pounds of fluids.
(2) & (3) See Table 6.2-6.

A capability for fault isolation and ready replacement of each module will be required. Modules of the "*" items will require the most frequent replacement.

Another item which is expected to require frequent replacement are the TV cameras. There are four in the basic building block and two in the Earth orbit module. A total of 14 spare cameras are required to achieve the required P_{ms} for 730 days. The following requirements for parallel and standby redundancy were identified.

Unified S-Band Transponder (U.S.B.)	1 parallel
S-Band Power Amplifier (1350-w)	1 parallel
S-Band Power Amplifier (50-w)	1 standby
Up-Date Receiver/Decoder	1 standby
Premodulation Processor	1 standby

In the case of the transponder and 1350-w amplifier which had been assumed to be modularized, the MARCEP analysis indicated that one of each type module was required to be redundant because of the critical downtime. Therefore, a total of one parallel transponder and amplifier were required as well as spares for each of the module types.

b) Crew Systems

Weight added - 859 pounds (all spares).

Significant weight items:

4 Spare EVA Suits	244 pounds
3 PLSS Repair Kits	60
3 Spare Refrigerator Compressors	78
12 Spare Intercom/Warning Sets	30
1 Spare set of Exercise Springs	55
2 Spare Refrigerator Motors	52
Miscellaneous	290
TOTAL	859 pounds

There was no requirement for parallel or standby redundancy for the crew system. Most items required few spares to achieve the 99% P_{ms} for the space station. An exception was the intercom/warning sets in the crew quarters which required 12 spares. Therefore, this item should get primary consideration for design for ready fault isolation and replacement.

There are a number of items in the system which realistically should not be spared at the complete assembly or installation level. Therefore, these items should be designed for repair at a lower level than that presently identified. These items include: washing machine, dispensary equipment, oven, hot water and cool water systems, refrigerator, cabinets, restraint system, tape recorder system. In the MARCEP analysis it was arbitrarily assumed that a repair kit would be used for some of these items instead of sparing the complete item. This also results in a lower system added weight.

c) Electrical Power

Weight added - 2970 pounds (755 pounds redundancies, 2215 pounds spares).

Again, for this system an initial analysis resulted in a high added weight being caused by the batteries, inverters and voltage regulators. It was considered practical to modularize the inverters and voltage regulators and, as a result, the 2970 pounds shown above is over 500 pounds less than when nonmodularization of these items was assumed. Significant weight items:

4 parallel voltage regulators + spare modules	660 pounds
1 parallel set of main contactors	42
1 parallel set of BC contactors	18
6 parallel inverters+ spare modules	420
4 spare VR fail sensors	99
3 spare battery chargers	53
3 spare booster converters	52
2 spare batteries	690
Miscellaneous	936
TOTAL	2970 pounds

The spare battery requirements are that due to the possibility of random failure. Scheduled replacements due to the one year battery life are not included here. However, a considerable spares weight saving, over 600 pounds, could be achieved if it were possible to replace individual battery cells instead of replacing the entire battery.

d) Environmental Control/Life Support

Weight added - 6898 pounds (4540 pounds redundancies, 2358 pounds spares).

Significant weight items:

2 standby parallel and 13 spare air purification compressors	79 pounds
6 spare catalytic oxidizers	96
1 parallel redundant O_2 tank (incl. O_2)	1850
1 parallel redundant N_2 tank (incl. N_2)	1345
2 standby and 9 spare water separators	109
4 parallel and 8 spare silica gel canisters	192
4 parallel and 8 spare zeolite canisters	219

4 parallel and 15 spare vapor compression units	885 pounds
6 spare reverse osmosis pumps	114
2 parallel E-3 fluid reservoir (incl. E-3 fluid)	340
Miscellaneous	1,639
Total	6,898 pounds

A trade was made later in the study sparing complete vapor compression units as compared to providing spares for components of the unit. Sparing the components resulted in a reduction of over 600 pounds in the weight added shown above. The apparently high amount of spares of some items is because the higher basic population for each component resulted from a complete EC/LSS being used in both the basic building block and Earth orbit modules of the combined mission.

The parallel redundancy indicated must be designed into the system. In addition, parallel redundancy is also required for a number of other components. This is discussed more fully in the EC/LSS description, Section 4.1 of Document D2-114014-1. Of particular concern is the indication that if the O_2 and N_2 supply system valves (shutoff, check, vent, and relief), pressure switches, and transducers cannot be replaced, then anywhere from 2 to 10 additional redundant components for each must be provided. Therefore, it would appear necessary to locate these components within the space station such that replacement is practicable.

e) Propulsion

Weight added--245 pounds (233 pounds of redundancy and 12 pounds of spares).

The propulsion system is used for only a small part of the total mission time. Therefore, the equipment failure rates and operating times were adjusted as required to achieve an equivalent probability of success for a 730-day mission. Because of the relatively low operating time, the redundancy and spares requirements are significantly lower than for the other major systems. Most of the redundancy weight is attributed to three parallel redundant helium pressurant tanks for a total weight of 175 pounds. Redundancy is also required on most of the valves, regulators, lines, and heat exchangers in the system.

f) Guidance and Control

Weight added--2656 pounds (953 pounds redundancies, 1703 pounds spares).

Significant weight items:

3 spare CMG spin motor/rotor assemblies	174 pounds
1 parallel fuel tank (incl. fuel)	226
1 parallel oxidizer tank (incl. oxidizer)	451
4 spare inverter electronic packages	228
5 spare BMAC packages	102
3 parallel sets of reaction jets	101
1 parallel and 5 spare inertial platforms	438
4 spare display electronics units	96
4 spare CMG control electronics assy	96
7 spare torquer electronics units	70
4 spare gyro display coupler	94
Miscellaneous	580
Total	2,656 pounds

The Sun sensor and horizon sensor packages were identified as being non repairable or nonreplaceable. Therefore, the subsystem reliability could only be improved by parallel and standby redundancy. To achieve this would require the following:

	Redundancy Required
Horizon Sensor (2)	8 (4 sets of 2)
Sun Sensor (2)	6 (3 sets of 2)

Providing four parallel sets of horizon sensors and three parallel sets of Sun sensors may be practicable. But consideration should be given to providing a replacement capability for the high failure rate part of the sensors.

The propellant storage, regulation and distribution components required three of four redundant components for each valve, filter, or regulator in the system. It may present a design problem to incorporate this redundancy without unduly complicating the system. Therefore, it would be advantageous to locate these components so they can be replaced and eliminate the need for extensive redundancy.

The CMG's were assumed to have replaceable rotor bearings, gimbal bearings, gimbal torquer assembly, gimbal pickoff, and spin motor/rotor assembly. If the CMG's cannot be designed for this level of replacement, but must be replaced as a complete unit, then the spares requirements will increase by over 2000-lbs.

g) Inflight Test System

Weight added - 373-lbs (all spares). Significant weight items:

4 spare safety monitor units	36-lbs
3 spare test display and control units	36
3 spare signal generators	66
2 spare counters	30
2 spare oscilloscopes	28
2 spare manual test units	40
7 spare flight director displays	7
Miscellaneous	130
Total	373-lbs

The inflight test system as analyzed in MARCEP included the main operation console displays and controls. There were a number of spares required for each of these items, but they were relatively light in weight and accounted for only a small part of the added weight.

h) Maintenance Equipment

Weight added - 41-lbs (all spares).

The major part of this weight is for two spare electron beam welders for a total of 18-lbs. The low added weight for this system is mostly due to the very low operating time required for this equipment.

6.3 MAINTENANCE REQUIREMENTS

6.3.1 MAINTENANCE DEFINITION

Maintenance can be defined as all the activities necessary to keep spacecraft subsystems in, or restore them to, a satisfactory operating condition. Scheduled maintenance is preplanned for accomplishment at given points or intervals. All other maintenance is classed as unscheduled. Typical activities which are included in each of these categories are as follows:

Scheduled Maintenance

1) Routine inspection, servicing, and preventive maintenance activities; e.g., replacement of filters, chemicals, wicking; inspecting and cleaning equipment; housekeeping functions; replenishment of expendables; calibration functions; lubrication.

2) Replacement of components which have a limited wearout life; e.g., batteries, lamp bulbs, reaction control engines.

Unscheduled Maintenance

1) Replacement of components because of random failures.

2) Repair of damage resulting from micrometeoroid impacts, docking operations, unanticipated human errors during maintenance, or handling of equipment.

3) Calibration or adjustments required to bring operation of newly installed or unduly deviating components within required tolerances.

6.3.2 MAINTENANCE GUIDELINES

The identification of maintenance requirements for the configurations reviewed in this study involved the description of the spacecraft subsystems down to the replaceable component level. An analysis of each of these components resulted in the identification of the equipment requirements, crew skills, repair times, and other maintenance aspects associated with replacement or repair of the item. Since scheduled maintenance can be predicted, and accounted for in system programming (including the provisioning of onboard resources), the burden of the study was to determine the probable extent and influence of unscheduled maintenance as a factor in mission accomplishment. The basic functions required to accomplish the unscheduled maintenance tasks which were considered in the maintenance analysis are described in the following paragraphs.

An initial requirement for unscheduled maintenance normally will develop from display indications or scheduled maintenance inspections.

When a subsystem malfunction is discovered, the crew member would assess fault isolation points by inserting the fault isolation cables into the subsystem test connectors and conducting the fault isolation routine specified for the equipment. From the fault indication, it will be determined whether the maintenance is to be performed in a shortsleeve environment or in an unpressurized or exterior area requiring a pressurized spacesuit and backpack operation. A determination also will made of the maintenance equipment required to correct the malfunction, and of the spares required. The maintenance equipment, including personnel and tool tethering devices, locomotion devices, and spares will be obtained from storage.

If the malfunction is within the normally pressurized area, the maintenance personnel can proceed directly to the fault location. If the malfunction is in an unpressurized area or external to the spacecraft and component redundancy has not been provided, egress through an airlock in a pressurized spacesuit with a backpack will be required. Crewmen required to work in a pressurized spacesuit must prebreathe pure oxygen for about 30 minutes at the spacecraft's normal internal pressure (7 psia) to avoid bends, before transfer to pure oxygen at the spacesuit pressure of 3.5 psia. For external maintenance, tethering devices and handholds as a means of manuevering will be necessary. Tethering devices will be required for the maintenance equipment and spares, for both exterior and interior maintenance.

A space environment factor which could affect the performance and scheduling of extravehicular maintenance is radiation hazard. This is greater at some localities in space than at others. Therefore, if extravehicular activity (EVA) becomes necessary it may be required to schedule it to avoid high radiation portions of the mission and the malfunction is such that a delay can be tolerated. Additional space environment factors which must be considered during the development of EVA maintenance techniques are temperature extremes, micrometeoroids, electrostatic charges, and light intensities.

After access has been gained to the area of the malfunction, verfication of the fault will be made; additional fault isolation may be required to identify items to be replaced. If at any time it is apparent that a malfunction cannot be corrected, the problem will be coordinated with Earth. If the problem is serious enough, it may require evacuation of the spacecraft and return of personnel to Earth (if possible), or retreat to the re-entry vehicle until return is possible. In most cases, an alternate mode of operation can be used until return to Earth or until the next resupply mission, at which time the necessary maintenance equipment or spares can be brought to the spacecraft.

Corrective action generally will consist of replacement of the faulty item, although in some cases, such as damage to structure, ducting, and large tanks, the maintenance will involve repair. During maintenance operations, provisions must be made for containing debris and fluids to prevent contamination of the area. This will be true both inside and outside the spacecraft. After the necessary corrective action has been taken, the installation will be inspected, serviced as required, and checked out. Any removed access panels or equipment will be replaced. Personnel, equipment and the removed item will return to the spacecraft, the maintenance equipment will be returned to storage, and the O_2 equipment, spacesuit, or backpacks serviced as required. The removed faulty unit will be inspected for any visual evidence of failure; minor tests with available maintenance equipment may also be conducted. If a small repair shop is available, minor repairs such as cleaning of parts, adjustment, or calibration of instruments, etc., can be performed. The maintenance action taken including pertinent data and observations, will be logged and the faulty item will be placed in storage for disposal. The maintenance data also will be transmitted to Earth at the next communication period.

6.3.3 ASSUMPTIONS

Proper performance of the maintenance analysis required that certain assumptions be established to ensure uniformity of effort and reduce the number of variables to a manageable level. Some of those used in this study include the following:

1) Unscheduled maintenance has priority over scheduled maintenance. Therefore, if maintenance resources (including crew skills) being used for scheduled maintenance are required for unscheduled maintenance, the scheduled tasks will be delayed until completion of the unscheduled task.

2) The mean maintenance repair times include the time from receipt of a fault indication through completion of the repair of replacement including checkout, and return of equipment to storage. The repair times are also based on the assumptions included herein being valid. Where EVA is required, the time reflects that necessary for checkout and donning the spacesuit, egress and ingress through the airlock, and doffing and servicing the spacesuit. Part of the time required for pre-breathing pure oxygen is assumed to be simultaneous with donning the spacesuit. This study assumed that the time for egress and ingress including donning and doffing the suit can be accomplished in 30 minutes.

3) Repair of subsystem malfunctions will generally be limited to replacement of components listed on the MARCEP data sheets. A limited number of repair functions are permitted and these are identified on the data sheets.

4) The spacecraft configuration with parallel and standby redundancies as determined by the computer optimization program is designed such that no single equipment failure will cause mission failure.

5) Capability to remove components used in fluid systems was assumed.

6) All plumbing runs will be continuous where possible. All joints which are not expected to require disconnection will be brazed or welded.

7) Interconnecting wiring which might be expected to require repair will use wire wrap or similar techniques for high reliability and easily repairable connections. This will eliminate the need for soldering and potential associated problems.

8) Sufficient experience will have been gained on previous manned space flights that equipment will be designed for maximum ease-of-maintenance considering the available personnel skills, support equipment, and expected space environment.

9) Adequate lighting capability will be provided for both external and internal maintenance.

10) The pressurized spacesuit and backpack have a normal endurance capability of 3 hours with additional reserve capability of 1 hour.

11) Spares will be stored in a location which is readily accessible to the crew. An inventory will be kept of the spares onboard and their storage location to facilitate finding the correct spare when needed; and where applicable, to aid in determining new spares needed at resupply.

12) Where feasible, it was assumed the onboard inflight test system which includes the display panel indications would isolate a failure to the replaceable component. This was assumed to be true for electronic equipment, in particular. Otherwise, it was assumed that test points would be available so a fault could be isolated to the replaceable component through the use of available maintenance and test equipment. It was also assumed that fault isolation could be performed without breaking electrical connections and that all components and test points would be accessible to a pressure suited man where this was required.

13) Electronic components requiring replacement will be designed as plug-in modules.

14) Components will be designed to require the use of no tools; or a minimum number of standard tools whenever possible.

15) Warning devices will be provided to give immediate warning of failure of critical components.

16) The interior volume must be sufficient to allow the crew to efficiently accomplish the mission.

17) The interior must be compatible with the maintainability requirements for accessibility, and operability requirements for monitor and control.

18) Safety considerations such as rounded corners, easy access to spacesuits, rapid exists, and enclosure of experiments and operations which could contaminate the spacecraft interior shall be incorporated.

19) The interior of the vehicle, including all access hatches are sized for the 10th through 90th percentile crewman in a pressurized spacesuit.

6.3.4 UNSCHEDULED MAINTENANCE REQUIREMENTS SUMMARY

A mission simulation model was designed to simulate the unscheduled maintenance requirements of a fully configured space station as developed by MARCEP to the desired level of mission success; and, to determine the effects of maintenance time, spares weight, resupply intervals or mission durations, and system reliability on the system. The simulation method uses the IBM General Purpose System Simulation (GPSS) Model III language that is operated on by the IBM 7094 digital computer.

Unscheduled failures were assumed to occur randomly within an assumed exponential distribution about the total system mean-time-between-failure (MTBF) rate. A separate small Fortran program was used to calculate the total system MTBF, including any parallel or standby components added to the basic system by the MARCEP, and the contribution that each of the component types made to the total system MTBF. Each time a failure was created, random numbers were generated to identify the subsystem and the component of that subsystem that failed. The probability that the failure was within a specific subsystem was directly proportional to: 1) the ratio of the subsystem failure rate to the total spacecraft failure rate; and 2) the ratio of the component failure rate to its subsystem failure rate. After the failed component had been determined, its number and weight were tabulated within the computer. The maintenance time that must be spent on the task was then calculated. Initially the mean-time-to-repair (MTTR) for each component type, as identified in the MARCEP analysis, is fed into the computer. However, in reality it is known that the actual repair times may actually vary considerably about the mean value. Therefore, the MTTR values entered into the program were multiplied by a number randomly picked from a log normal cumulative distribution curve. This resulted in the actual repair time varying from 0.1 to 10.0 times the expected MTTR. The data on maintenance time was then recorded. After each day of simulation, statistics were tabulated on the maintenance time. At the end of the designated mission time, data was gathered on failures, spares weight and maintenance time. The simulation was then continued until the mission time had been simulated 100 times. The statistics for the total simulation of 100 cycles of the selected mission duration or resupply interval were then tabulated.

Previously, in Paragraph 6.2, curves were presented showing weight added to a basic spacecraft system for various mission intervals to achieve a 99% probability of mission success for 730 days. The amount of this weight actually expected to be used to correct random component failures (unscheduled maintenance) is shown in Figure 6.3-1 for the combined mission. The maximum weight of spares expected to be used during any one 90-day period is about 375 pounds, which represents about 7.5% of the weight initially added to the system for a .99875 P_{ms} for 90 days. It is also noted that 95% of the time the weight of spares used will be 200 pounds or less. The mean expected spares usage for 90 days is 25 pounds.

Figure 6.3-2 presents the expected spares usage data for the basic flyby mission. As would be expected, the spares usage is less for this mission. The maximum usage for 90 days is 225-lbs and the mean usage is 58-lbs.

The expected impact of the unscheduled maintenance on the mission and crew operations as derived from the 100 mission simulations is shown in Figures 6.3-3 thru 6.3-7 . Figure 6.3-3 indicates that on 88% of the days there will be no unscheduled maintenance required for the combined mission. If all the unscheduled maintenance required could be averaged out over the total mission, the mean daily repair time would amount to only 22 minutes. From Figure 6.3-4, for the basic flyby mission, 90% of the days will require no maintenance and the mean daily repair time is 17 minutes.

Figure 6.3-5 shows the repair task time distribution for the 12% of the days on the combined mission during which some failure occurred and unscheduled maintenance may be required. The chart reflects that about 8% of the failures will require no maintenance, 22% of the tasks will require between 0 and 0.5 hours, and 96% of the tasks require 10.5 hours or less. However, the mean task time is about 147 minutes (2.5 hours) because of the effect of a few repairs which require a large amount of time. The 8% of the failures for which no maintenance is required means that for those failures there is parallel or standby redundancy available, and replacement of the failed item is not required. Figure 6.3-6 presents the same type of data for the basic flyby mission. In general, there is a very close correlation between the two missions for distribution of the repair task time.

Figure 6.3-7 graphically portrays the percent of total system failures and repair time which is attributable to each subsystem for the combined mission. It is of interest to note that the EC/LSS and Inflight Test System have the highest percentage of system failures. However, the EC/LSS requires a much greater proportion of the repair time. This is because the Inflight Test System includes all of the control panel displays and indicators which, while they fail relatively frequently, can be replaced rather easily. The higher percentage of repair time compared to failures for the Communications and Crew Systems indicates that the average maintenance action for each of these subsystems requires more time than for the other subsystems. This is confirmed in Table 6.3-1 which breaks down the failure data for each subsystem. As noted, the total average minutes per day for unscheduled maintenance is only 22 minutes.

Similar data for the basic flyby mission is given in Figure 6.3-8 and Table 6.3-2 . The percentage breakdown is generally comparable to the combined mission. The differences cannot be attributed to the increase in onboard equipment of some of the systems for the combined mission.

Figures 6.3-9 and 6.3-10 show a typical occurrence of unscheduled maintenance tasks for each mission for 1 year's time as determined by the systems simulation. The mean task repair time and mean daily repair time numbers shown on the figures are as determined by 100 simulations of a 730 day time period. The numbers are not necessarily the mean values for the 360

TABLE 6.3-1 - SUBSYSTEM UNSCHEDULED MAINTENANCE REQUIREMENTS

COMBINED MISSION

SUBSYSTEM	% OF TOTAL REPAIR TIME	MEAN DAYS BETWEEN FAILURES	AVERAGE MIN/FAILURE	AVERAGE MIN/DAY
EC/LSS	49.19	20	211	10.5
INFLIGHT TEST	9.10	39	79	2.0
GUIDANCE AND CONTROL	14.87	39	132	3.4
COMMUNICATIONS AND DATA MANAGEMENT	12.60	47	136	2.9
CREW SYSTEM	11.07	68	169	2.5
ELECTRICAL POWER	2.54	155	83	0.6
PROPULSION	0.50	6640	605	0.1
MAINTENANCE EQUIPMENT	0.13	18250	503	0.1
TOTAL OR AVERAGE	100.00	7.0	152	22.1

TABLE 6.3-2 - SUBSYSTEM UNSCHEDULED MAINTENANCE REQUIREMENTS

FLYBY MISSION

SUBSYSTEM	% OF TOTAL REPAIR TIME	MEAN DAYS BETWEEN FAILURE	AVERAGE MIN/FAILURE	AVERAGE MIN/DAY
EC/LSS	51.38	27	237	8.8
INFLIGHT TEST	12.03	40	81	2.0
GUIDANCE AND CONTROL	10.86	48	89	1.9
COMMUNICATIONS AND DATA MANAGEMENT	12.88	59	131	2.2
CREW SYSTEM	7.32	136	170	1.3
ELECTRICAL POWER	3.13	170	91	0.5
PROPULSION	2.35	2360	950	0.4
MAINTENANCE EQUIPMENT	0.04	18250	133	0.1
TOTAL OR AVERAGE	100.00	8.7	150	17.2

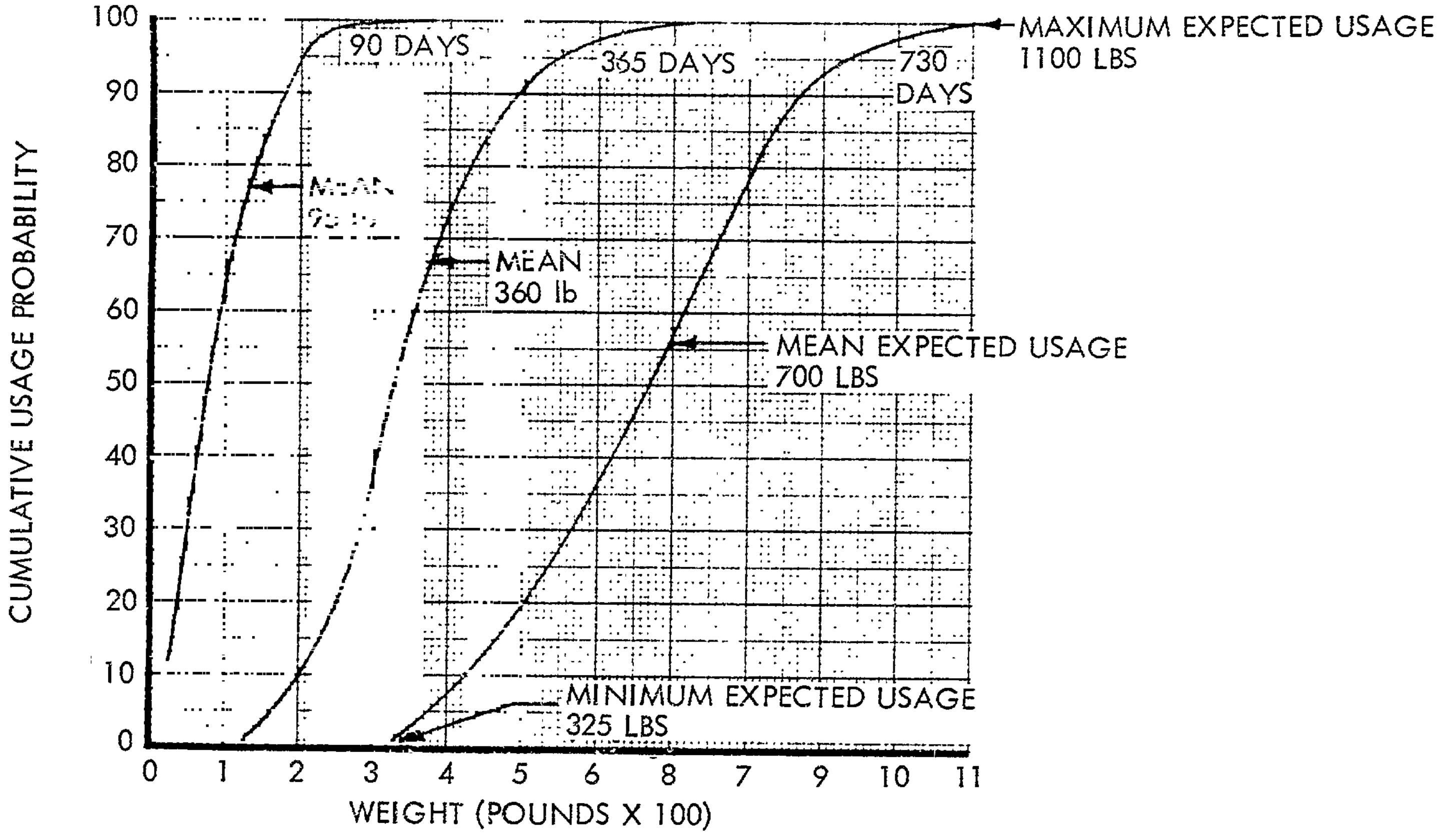


Figure 6.3-1: SPARES WEIGHT USED
Combined Mission

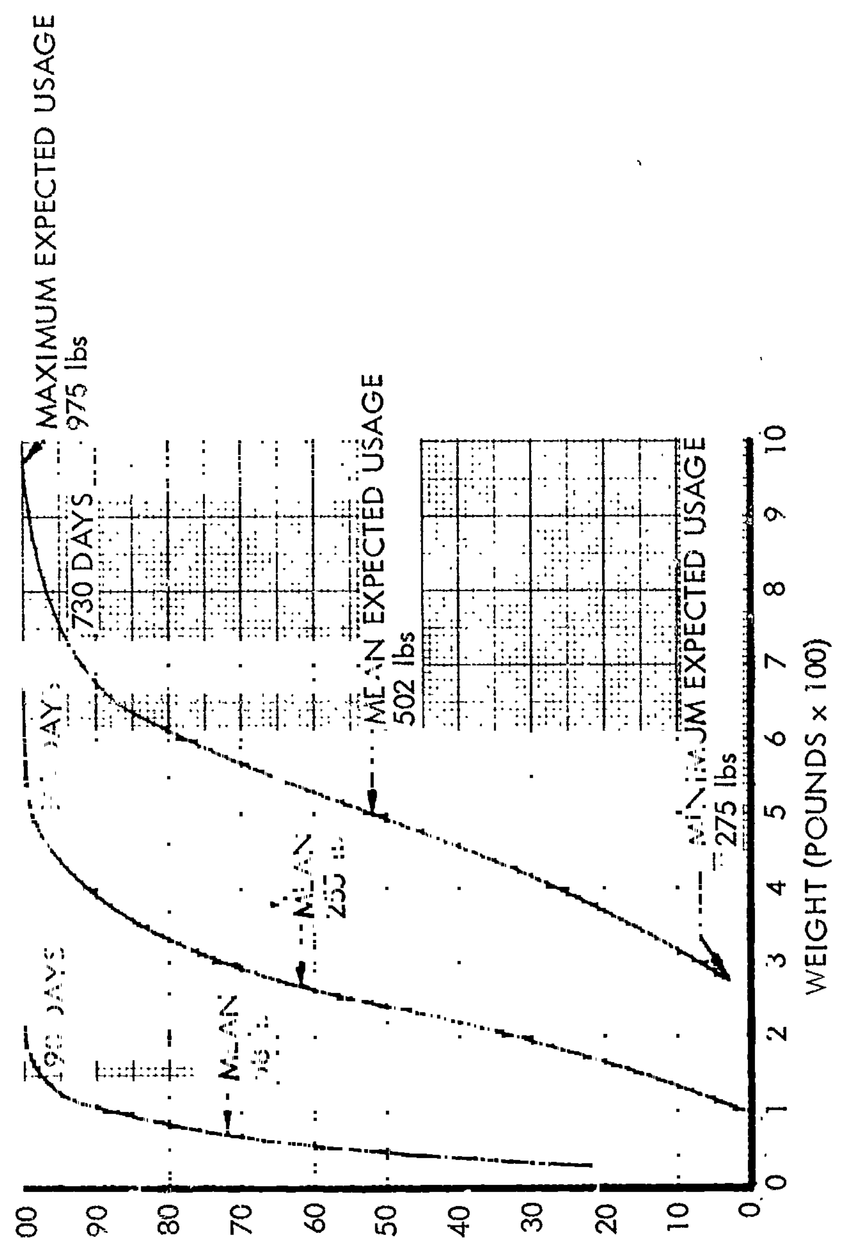


Figure 6.3-2: SPARES WEIGHT USED
Flyby Mission

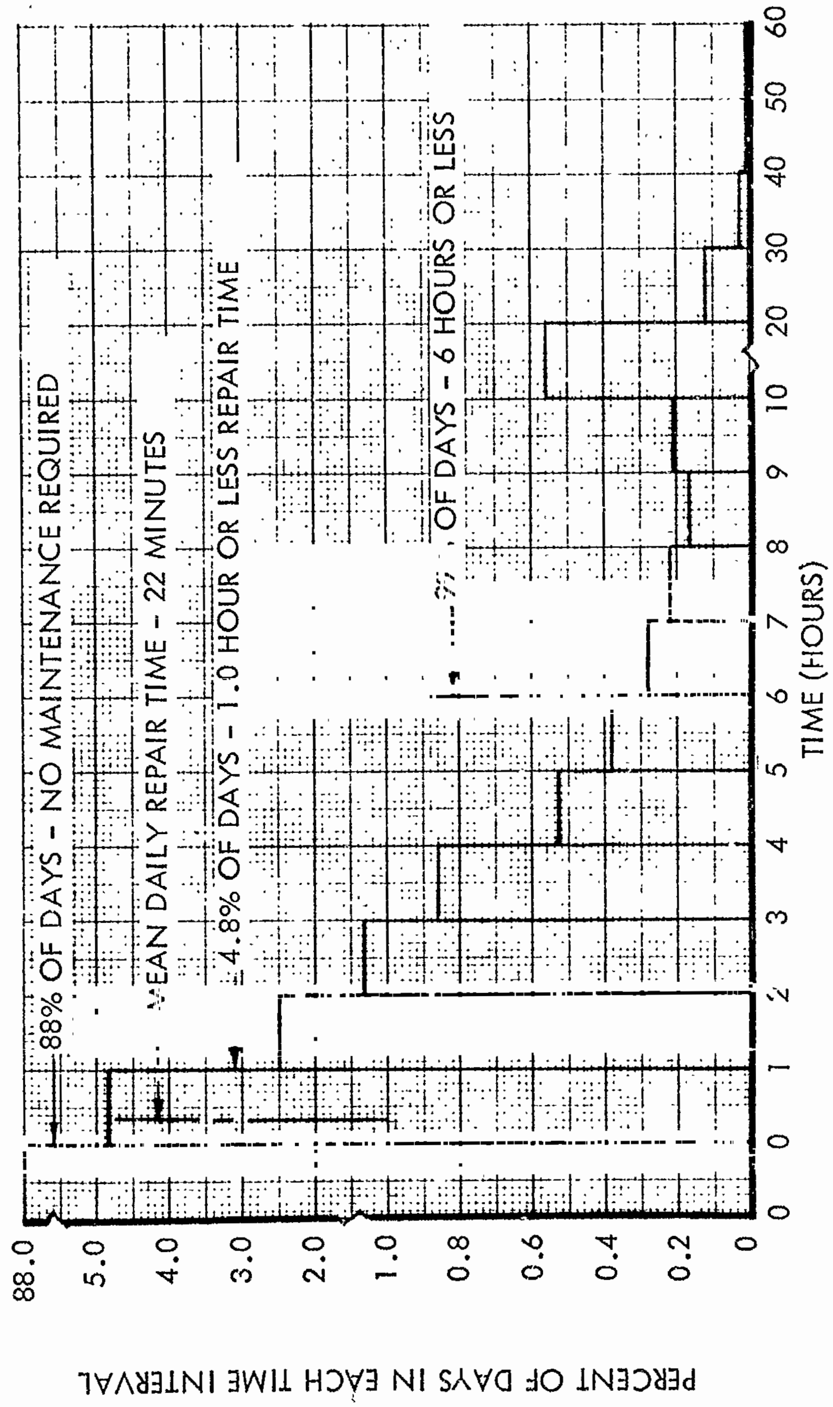


Figure 6.3-3: DAILY REPAIR TIME DISTRIBUTION
Combined Mission

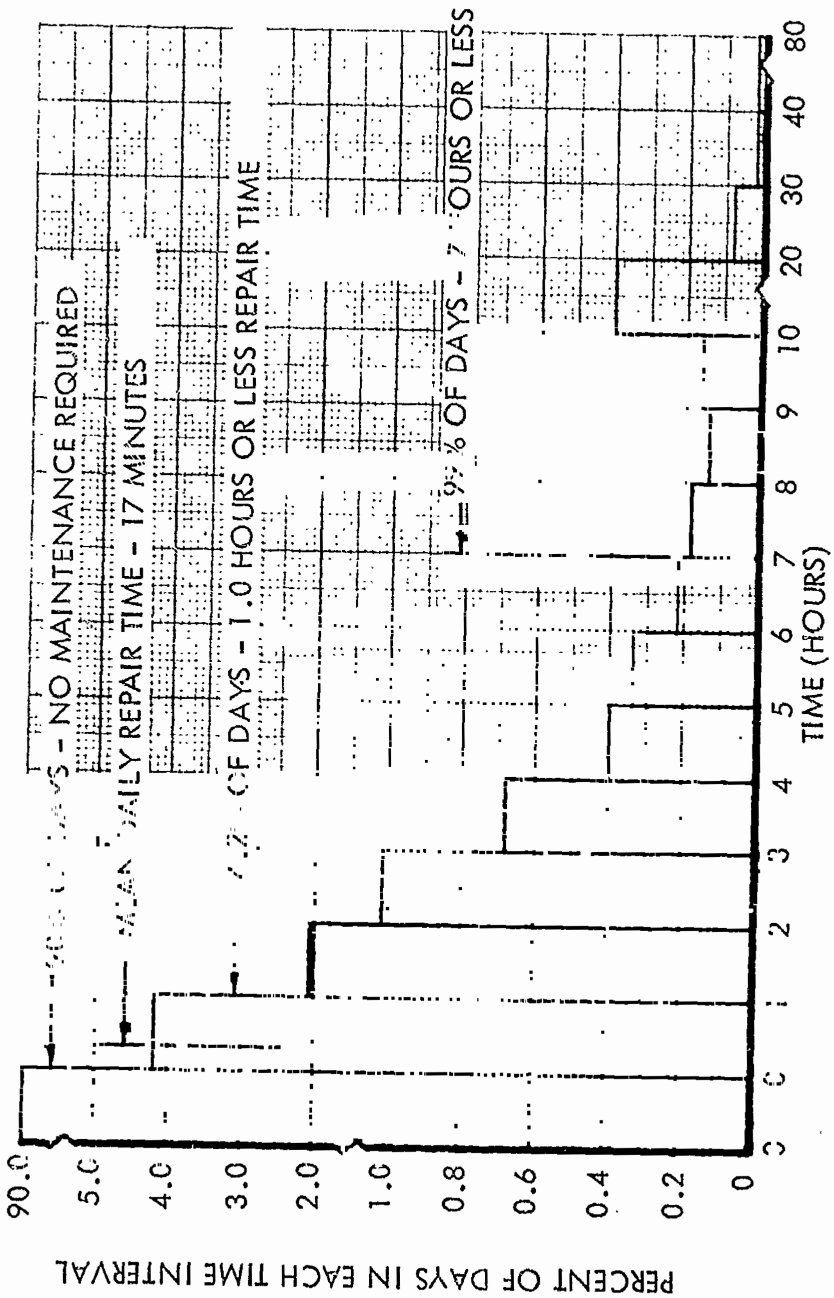


Figure 6.3-4: DAILY REPAIR TIME DISTRIBUTION
Flyby Mission

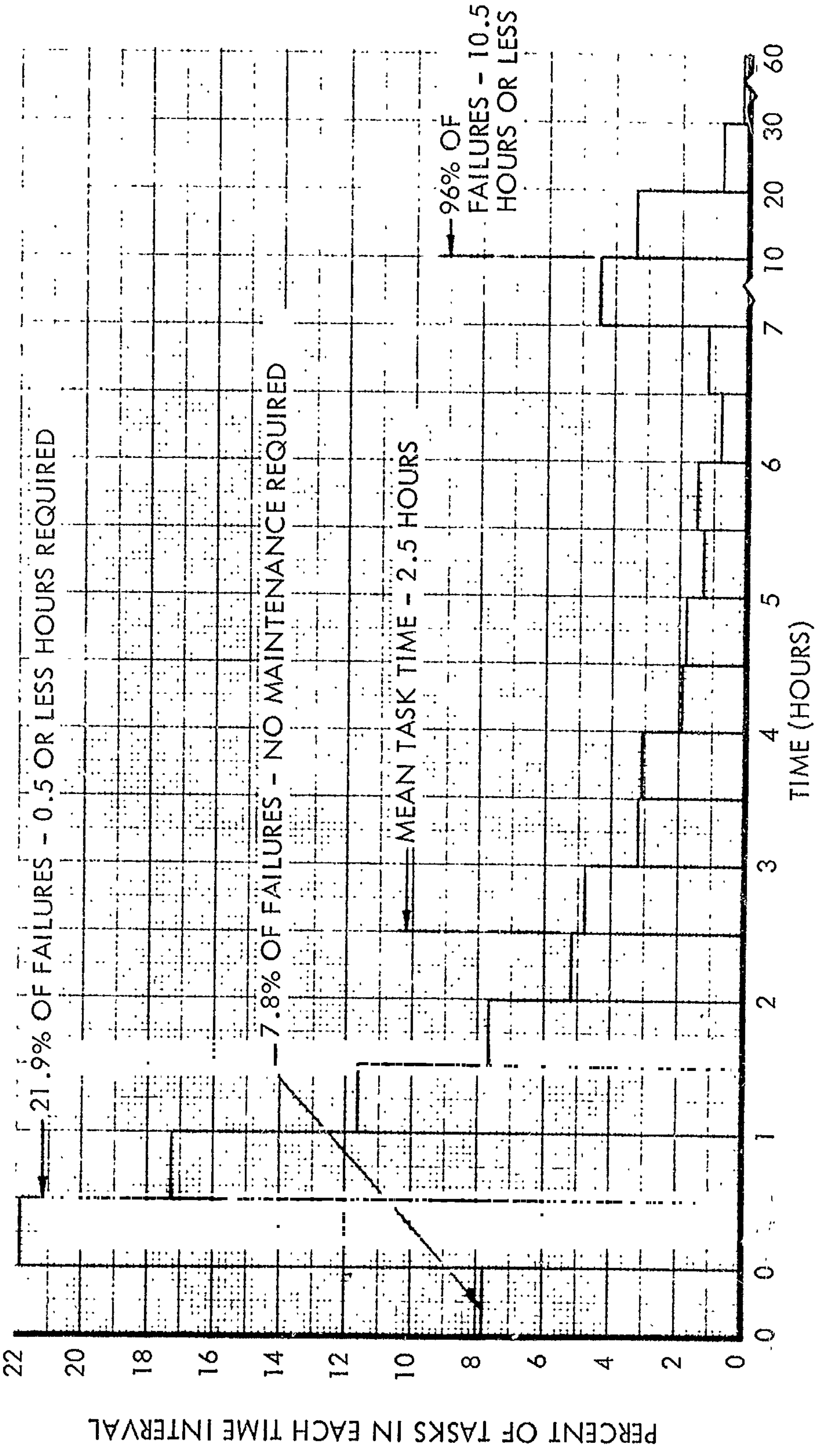


Figure 6.3-5: REPAIR TASK TIME DISTRIBUTION
Combined Mission

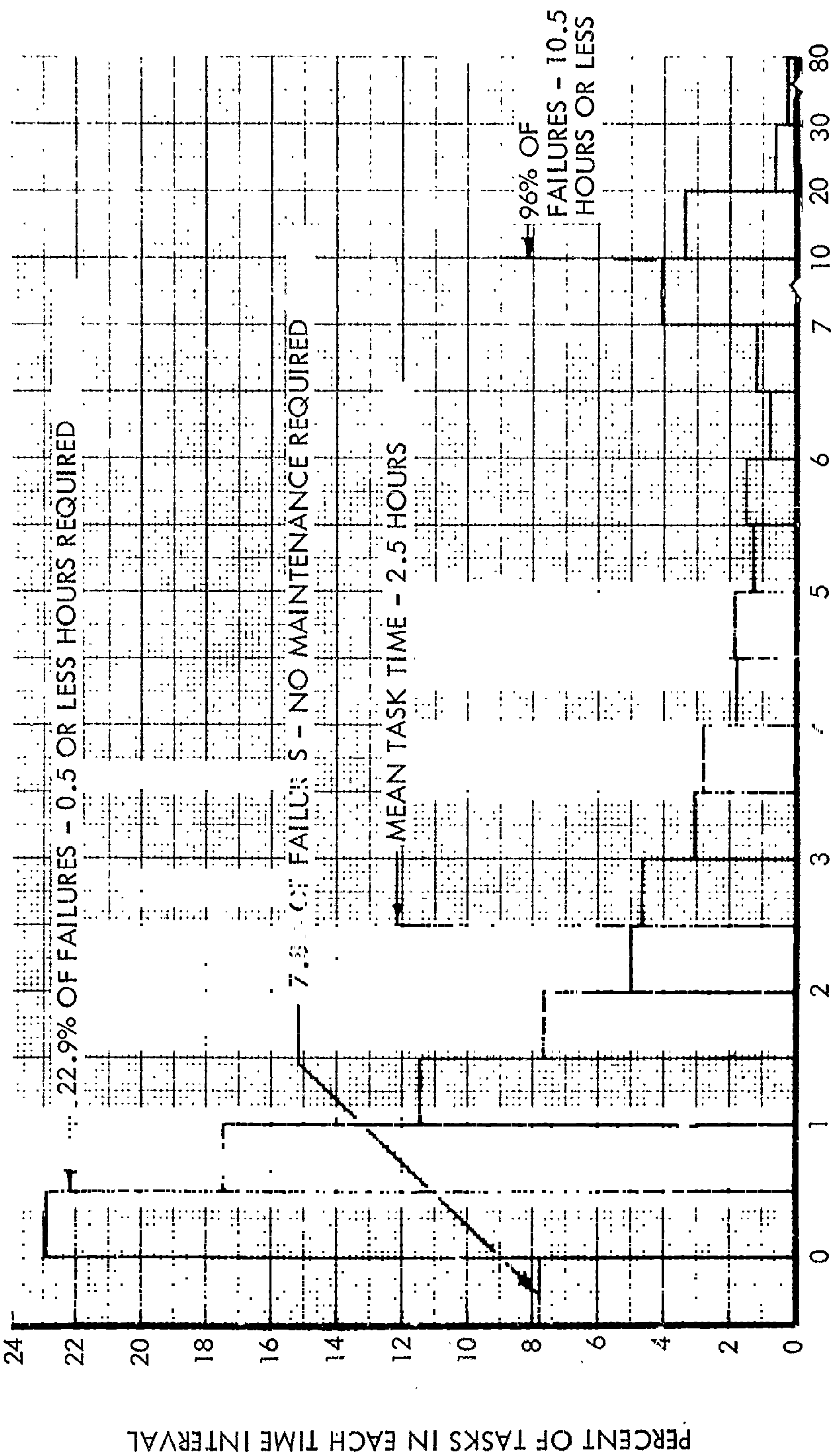


Figure 6.3-6: REPAIR TASK TIME DISTRIBUTION
Flyby Mission

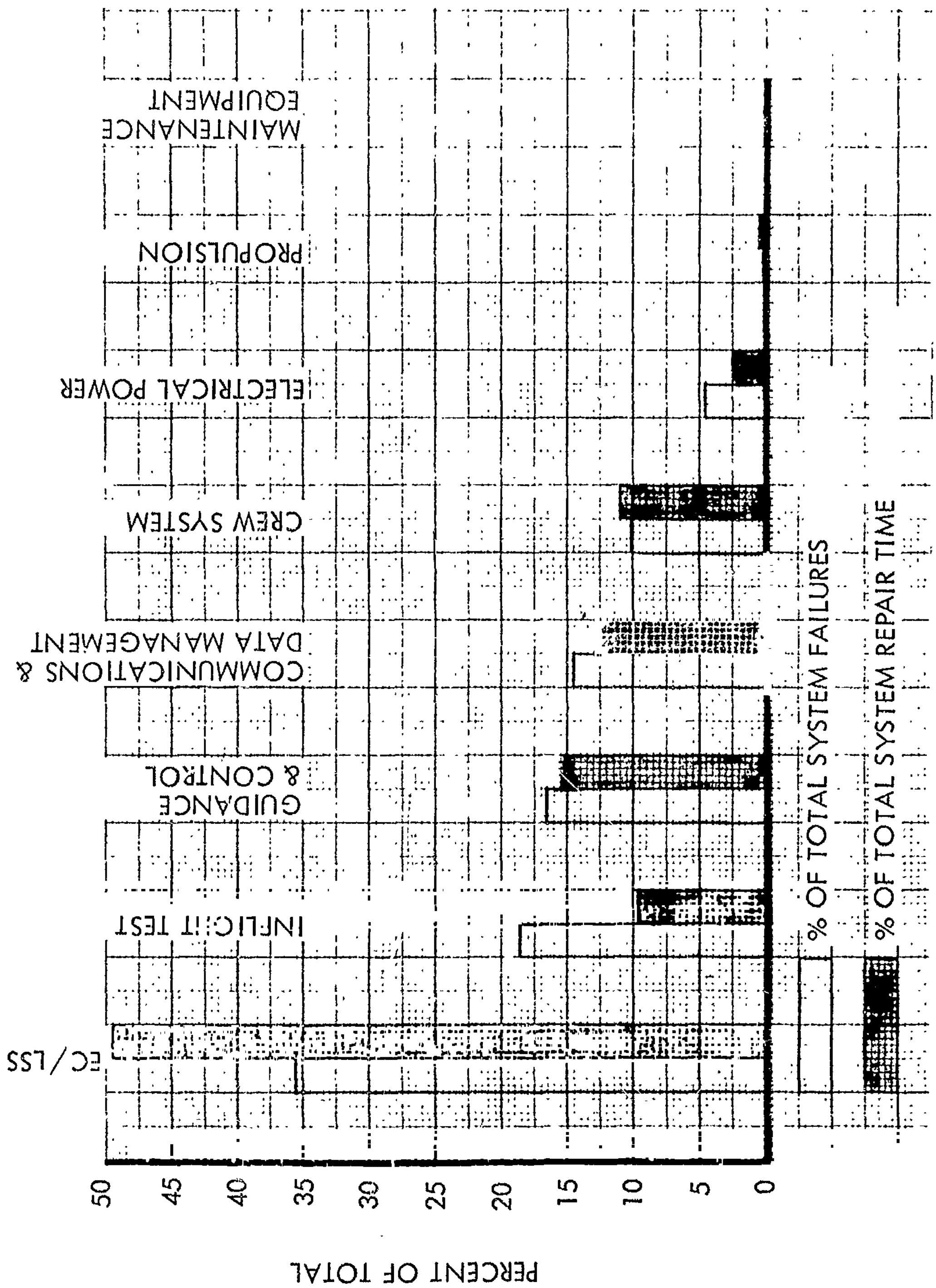


Figure 6.3-7: SUBSYSTEM FAILURES & UNSCHEDULED MAINTENANCE REPAIR TIME
Combined Mission

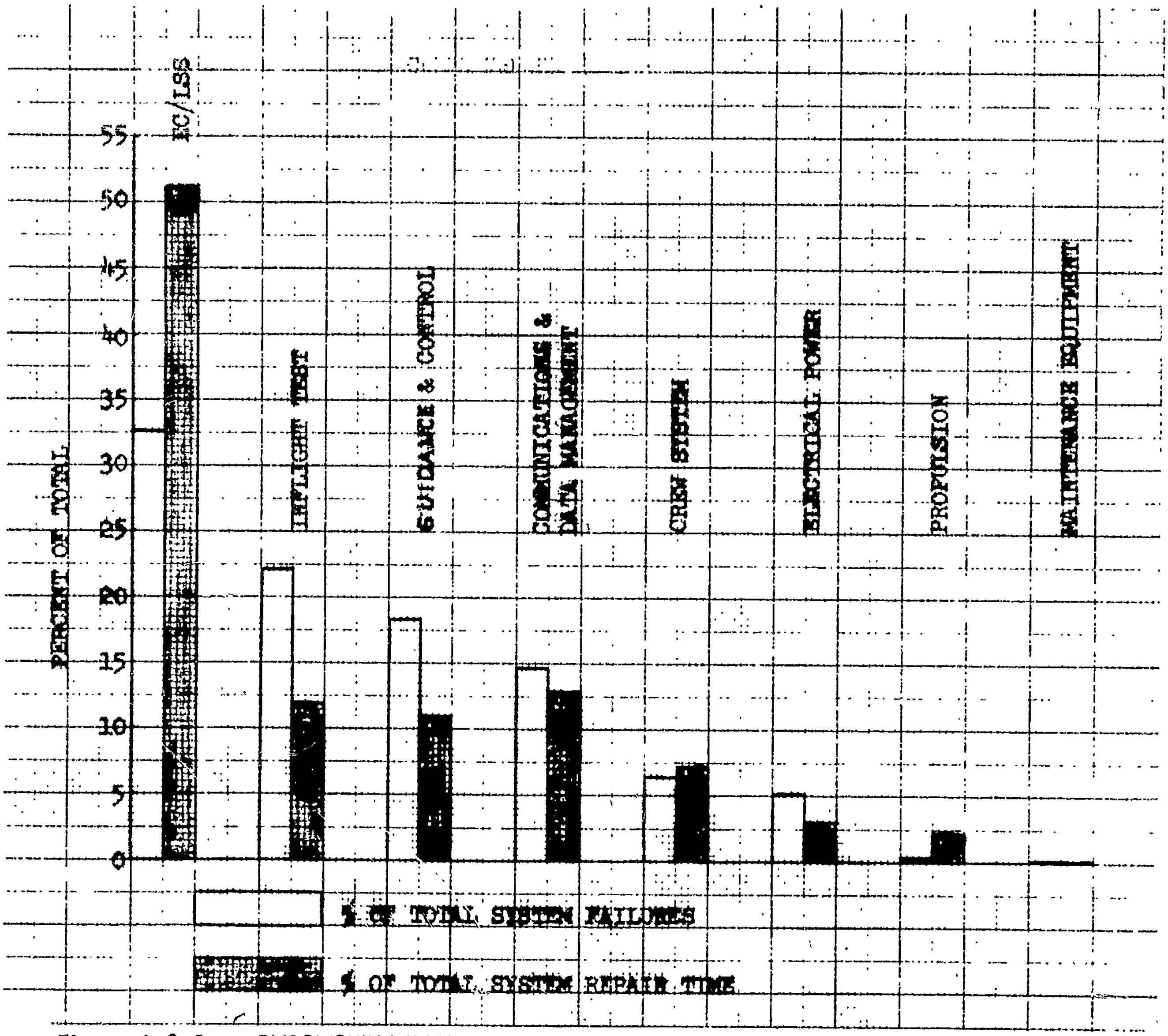


Figure 6.3-8: SUBSYSTEM FAILURES AND UNSCHEDULED MAINTENANCE REPAIR TIME Flyby Mission

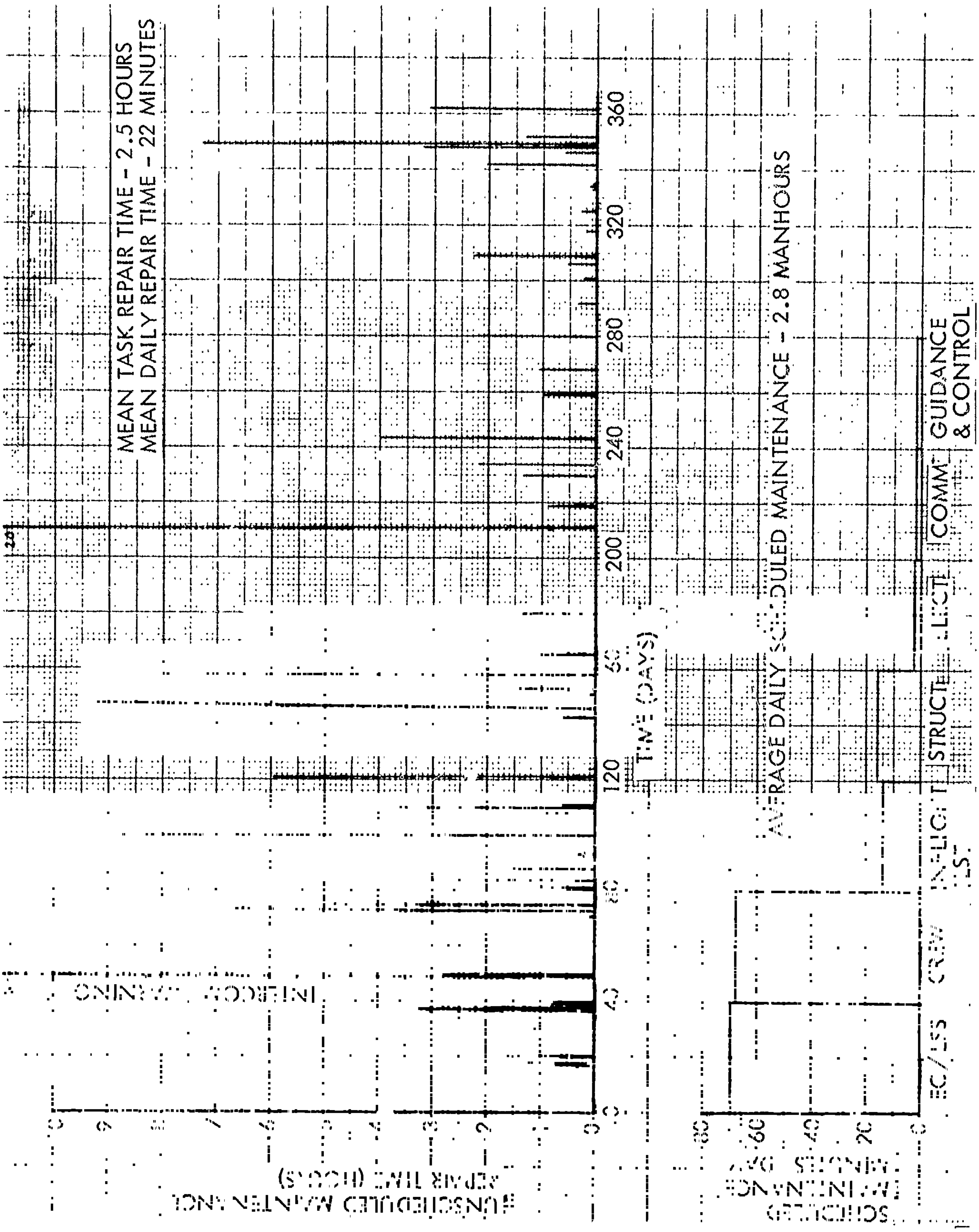


Figure 6.3-9: MAINTENANCE TIME REQUIREMENTS
Combined Mission

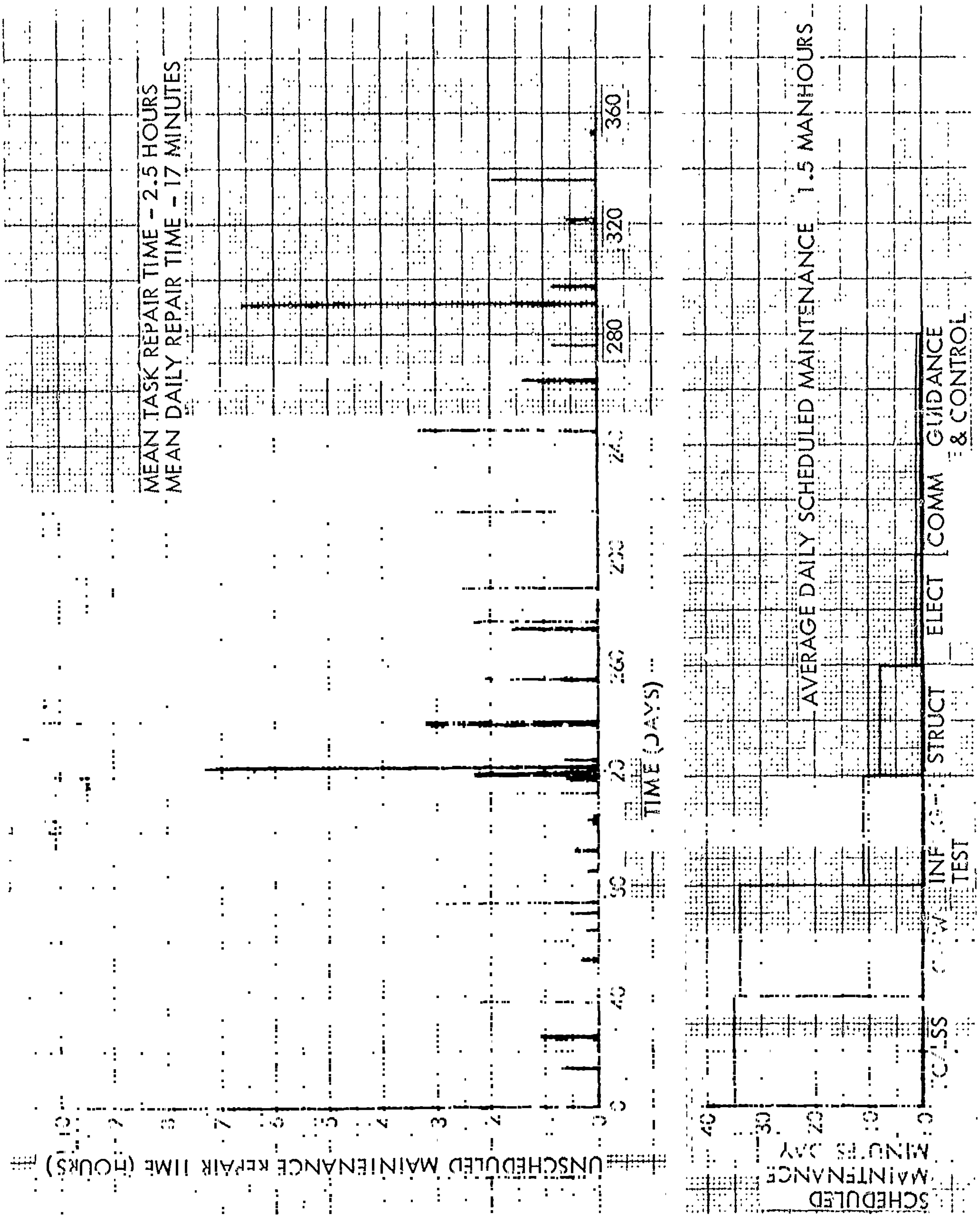


Figure 6.3-10: MAINTENANCE TIME REQUIREMENTS
Flyby Mission

days simulated on the figure. Also shown are the expected scheduled maintenance requirements which are discussed further in the following paragraph.

6.3.5 SCHEDULED MAINTENANCE REQUIREMENTS SUMMARY

The NAS2-3705 contract (Study of Maintainability for Long-Duration Manned Space Flight) included an extensive analysis of scheduled maintenance that involved typical spacecraft systems for an Earth orbit mission which compare favorably with the systems being used for this mission. Therefore, the results of that study are considered applicable here.

The scheduled maintenance requirements, which by definition occur at preplanned time intervals instead of randomly, were calculated manually. The requirements were initially identified in the maintenance task analysis of the NAS2-3705 contract. Table 6.3-13 summarized by subsystem the total man minutes and average man-minutes per day for the scheduled maintenance required at the different time intervals for the combined mission. It is expected that with the proper scheduling these tasks could be apportioned over all the days of each 90 day interval so the workload would be relatively evenly distributed over each day. It is noted that an average of about 168 man-minutes (2.8 man-hours) per day are required to accomplish the identified scheduled maintenance. The life support system (environmental control included) and the crew system, which includes the general housekeeping functions, together account for about 69% of the scheduled maintenance. Table 6.3-14 presents the scheduled maintenance estimates for the basic flyby mission which requires an average of about 1.5 man-hours per day.

FOLDOUT FRAME

TABLE 6.3-3 - SUBSYSTEM SCHEDULED MAINTENANCE REQUIREMENTS
COMBINED MISSION

SUBSYSTEM	MAN-MINUTES/MAINTENANCE INTERVAL (DAYS)						AVERAGE MAN-MINUTES/DAY
	1D	3D	7D	21D	30D	90D	
LIFE SUPPORT SYSTEM	20	30	90	60	690	260	70.6
CREW SYSTEM			480		80	80	68.4
INFLIGHT TEST SYSTEM	13				30		14
STRUCTURE					240		8.0
ELECTRICAL POWER			15				2.1
COMMUNICATIONS						110	1.2
GUIDANCE AND CONTROL			10			30	1.4
TOTAL MAN-MINUTES	33	30	595	60	1040	480	166.7

TABLE 6.3-.4 - SUBSYSTEM SCHEDULED MAINTENANCE REQUIREMENTS

FLYBY MISSION

SUBSYSTEM	MAN-MINUTES/MAINTENANCE INTERVAL (DAYS)						AVERAGE MAN-MINUTES/DAY
	1D	3D	7D	21D	30D	90D	
LIFE SUPPORT SYSTEM	10	15	45	30	345	130	35.3
CREW SYSTEM			240		40	40	34.2
INFLIGHT TEST SYSTEM	10				30		11.0
STRUCTURE					240		8.0
ELECTRICAL POWER			10				1.4
COMMUNICATIONS						110	1.2
GUIDANCE AND CONTROL			10				1.4
TOTAL MAN-MINUTES	20	15	305	30	655	280	92.8

APPENDIX I

APPLICATION OF EARTH ORBITAL EXPERIMENT PROCEDURE TO MARS FLYBY

1.0 SUMMARY

The major experiment groups planned for the 1975 Mars Flyby were examined briefly to determine the value of performing practice or "dry runs" of them in Earth orbit. All experiments were determined to benefit from Earth orbit operations to a high degree. However, some of the experiments can contribute almost nothing to fulfillment of Earth orbital objectives. The others may contribute considerably. The summarized qualitative value of conducting these experiments in Earth orbit is displayed in the following table:

Experiment	Benefit to 1975 Mars Performance	Contribution to Earth Orbit Objectives
40 inch Aperture Telescope Obs.	Full	Full
Panoramic Camera Photography	Full	Full
Enroute Experiments; Exobiology	Full	Almost Full
Mars Atmospheric Probes	Full	Little or None
Mars Orbiter	Considerable scaling required	Possibly Much
Mars Surface Sample Return	Some scaling required	None
Mars Lander	Some scaling required	None

2.0 INTRODUCTION

Substantial differences exist between the environmental and operational conditions prevailing in Earth orbit from those on a flyby mission. The following paragraphs discuss generally the effects these will have on the validity of the Earth orbital work as a preparation for the mission. In addition, comments will be made on the extent to which these checkout procedures may contribute to Earth orbital (EO) objectives.

Table I-1 is a matrix of the major flyby experiments displayed against the major differences existing between Earth orbital conditions and those of the Mars Flyby.

The specific qualitative effect of each major environmental difference on each of the seven major experiment groups is noted briefly in the appropriate box. These are of course only first-look effects. Many alternative methods exist for accomplishing Earth-orbital checkout of Mars experimental procedures. Decisions on these alternatives must be made at the time of the Mars experiment design and the final version of the Earth orbital experiments.

In the column at the left of Table I-1 is a summary statement of the the validity of the trial run in Earth orbit of each of the seven Mars experiments. Comments on these results are given in the following pages in the order the experiments are listed in the table.

2.1 40-INCH APERTURE TELESCOPE OBSERVATIONS

The 40-inch telescope is central to the Mars Flyby expedition. This is because the high resolution color photographs will be direct (not facsimile) and therefore the best detail of the surface available from the expedition. The telescope is also critical to the Flyby operations as it is used to select the locations for deployment of the MSSR and the Lander.

Table I-1, column 1, shows the atmosphere difference between Earth and Mars as having no first-order effects. Filters, film and exposure programs designed specifically for Mars, and Earth orbital use will not be of direct assistance. As shown in column 5, solar intensity variation from Earth to Mars will influence these designs. Faster angular rotation of Mars target point may very easily be checked out in Earth Orbit. In summary, all or nearly all of these Mars procedures may be checked out while fulfilling Earth orbital objectives.

2.2 PANORAMIC CAMERA PHOTOGRAPHY

Generally the same environmental differences apply to the camera as to the telescope. The panoramic camera will probably be mounted to the spacecraft instead of having its own stabilization as does the telescope. The accomplishment of earth orbital objectives will contribute directly to the Mars Flyby. The film design and exposure program for the flyby mission will be assisted by data taken on Voyager missions.

MARS FLYBY EXPERIMENTS (MARS OBJECTIVES)	1 ATMOSPHERE (MARS: VM7) SURFACE DENSITY gm/cm^3		2 DENSITY @ 150 Km gm/cm^3		3 TRAJECTORY SPEE RELATIVE VELOCI feet/second	
	FLYBY 6.82×10^{-6}	E.O. 1.225×10^{-3}	FLYBY 9.18×10^{-12}	E.O. 1.836×10^{-9}	FLYBY 32,000	E.O. 25,0
	EFFECTS OF DIFFERENCES					
I. 40 INCH APERTURE TELESCOPE OBSERVATIONS	Mars atmosphere probably more transparent than Earth. Effect of composition needs further study. No further effects.				Angular velocity increas from about 0.016 radian second in E.O. to 0.026 0.035 in Flyby. No operational or design ch required.	
II. PANORAMIC CAMERA PHOTOGRAPHS						
III. ENROUTE EXPERIMENTS INCLUDING EXOBIOLOGY	Proximity of Earth and Mars not relevant. Good calibrations on Sun, Jupiter, for planets, asteroids, stars.					
IV. ATMOSPHERIC PROBES	No change in operational procedures nor probe design. Good calibration of instrument.					
V. MARS ORBITER	No effect unless atmosphere used for retro and orbit forming. No operational change.				Only small injection eng required in E.O. Heat s or retro propulsion will dummy only.	
VI. MSSR	Heat shield area and retro (landing) propellant adjusted for Earth gravity and atmospheric profile. No operational change.				Probe deployed to be nea plane of spacecraft abou 9 days after release fro Ample ΔV capability ex for plane change as requ Less propellant required rendezvous in E.O.	
VII. MARS LANDER	Heat shield area and retro (landing) propellant adjusted for Earth gravity and atmospheric profile. No operational change.				Heat shield area adjuste compensating density and velocity effects.	

FOLDOUT FRAME 1

MAJOR DIFFERENCES BETWEEN CONDITIONS IN EARTH ORBIT (E.O.) AND THOSE ON MARS FLYBY

	4		5		6 COMMUNICATIONS DISTANCE		7	
ʀY SPEED VELOCITY cond	ALTITUDE N.M. ABOVE SURFACE		SOLAR DISTANCE A.U.		PROBE-SPACECRAFT NM		PROBE - DSIF AU	N.M.
E.O. 25,000	FLYBY 460	E.O. 260	FLYBY 1 - 2.2	E.O. 1	FLYBY 100 - MR*	E.O. 100 - 1250	FLYBY 0.5 - 3.0	E.O. 250 - 1,
CES ON VALIDITY OF EARTH-ORBITAL "DRY-RUN" OF FLYBY								
increase radians/ 0.026 - No sign change			E.O. and Flyby astronomical experiments both are parts of continuous program of similar Solar System observations.		All design and operations for E.O. will be directly applicable to Flyby.		N.A.	
			No effect except changes of exposure for local light conditions and film used.		N.A.		N.A.	
			Shielding of experiments from radiation generally more difficult in E.O.		N.A.		N.A.	
			NO EFFECT		Communications procedures distances and geometery all very similar in E.O. and Flyby.		N.A.	
ion engine Heat shield on will be	NO EFFECT		NO EFFECT		Tracking and line of sight (L.S.) communications @ about 2,[illegible]00 NM in E.O. versus maximum range of many thousand miles on Flyby.		Probe to DSIF communicat cannot be practiced to a value in E.O.	
be near ft about ase from E.O. lity exists as required. equired for			NO EFFECT		L.S. communications with surfaced MSSR @ about 1,350 NM in E.O. versus about 2,500 on Flyby. Departure unlimited on Flyby approach. (See Figure)			
djusted for ty and	NO EFFECT		NO EFFECT					

*Max. Rng.

FOLDOUT FRAME 2

Table I-1: VALUE OF SIMULATING MARS FLYBY EXPERIMENTS IN EARTH ORBIT

	8		9
IF M.	PLANETARY GRAVITY FIELD cm/sec^2		SUMMARY OF VALIDITY OF EARTH - ORBITAL EXPERIMENT "PRACTICE"
O. 0 - 1,250	FLYBY 375	E.O. 980	
	NO EFFECT		Earth Orbital checkout of telescope operation will be fully effective for Mars Flyby provided faster angular passage of Mars is allowed for. E.O. objectives accomplished.
	NO EFFECT		Panoramic camera checkout in E.O. will be fully effective providing differences in angular passage and light conditions @ Mars are an anticipated. E.O. objectives accomplished.
	NO EFFECT		All phases of Enroute experiments, particularly with astronomy and control specimen behavior will be fully utilized in fulfilling E.O. objectives.
	Measured accelerations and impact pressures will tend to be higher on E.O. deployment. No operational change.		All phases of atmospheric probe experiment may be checked out in E.O., but without any new achievement in E.O. objectives.
nunications d to any	No effect unless atmosphere used for retro and orbit forming. No operational change.		Deployment and tracking of Orbiter can be effectively simulated. It may contribute to economic but not scientific advance in E.O. data gathering. No value in DSIF checkout.
	Launch propulsion system must be larger to attain Earth Orbit than Mars design first stage. No operational change.		Checkout of all phases of MSSR fully effective in E.O., but no E.O. objectives will be achieved. Rendezvous will require launch of sample on later orbit than deployment, and before spacecraft orbits 1,350 NM beyond deployment site.
	Retro propulsion for landing impact must be enlarged, or compensating effect of Earths atmosphere used to accomplish landing from E.O.		Value of checkout in E.O. generally limited to deployment. No E.O. objectives may be realized.

FOLDOUT FRAME 5

2.3 ENROUTE EXPERIMENTS INCLUDING EXOBIOLOGY

The Mars Flyby enroute experiments are in almost every sense a direct extension of the experiments to be conducted in Earth orbit in fulfillment of purely Earth orbital requirements.

Of the Enroute experiments, only one group, that directly pertaining to the Mars surface samples, is not affiliated with the Earth orbital experiments. In a larger sense however, even this is an extension of the investigations of the reactions of Earth life forms to the orbital conditions: weightlessness, isolation, solar radiation, and the particular design of experimental laboratory.

Table I-2 gives one example of the type of improvement the flyby mission will offer on Earth orbital astronomical data gathering. Somewhat closer approaches will be made to Jupiter and Saturn. But much greater differences in the approach distances will pertain to such targets as Mars satellites Demios and Phobas and asteroids Medusa and Xanthippe.

In summary, all preparation for the Mars Flyby Enroute Experiments will contribute directly to Earth orbital objectives.

2.4 MARS ATMOSPHERE PROBES

By the time of the subject Earth Orbital experiments, there will be very little information to be collected on the Earth atmosphere that can be obtained by the Mars atmosphere probes. Launching the probes over the ocean or unpopulated regions and recording the data will be essentially the same in Earth orbit as on the Mars flyby. There will be no need to duplicate the deployment 5 - 7 days before Mars encounter except as necessary in time-line studies of encounter procedures. These can be simulated without actual launch. Readout of data will be from a relatively short distance, both in Earth orbit and on flyby. Accurate tracking will not be necessary, as the precise landing spot is not important. However, the relative position of the probes to each other as they enter will be of interest in case there are significant differences in the readings of the several probes.

Table I-2: ENROUTE EXPERIMENTS

ASTRONOMY: (Using 1 meter telescope)

- Photographic and Spectral Analyses of Bodies in Solar System:

		Time in Mission	Closest Approach	Least Distance From Earth
Planets:	Jupiter	30 days	4.16 A.U.	4.2 A. U.
	Saturn	220 days	7.64 A.U.	8.54 A.U.
Phobos and Deimos		147 days	$<$10,000. KM	0.5 A.U.
Meteoroids, Asteroids:				
	Medusa	300 days	0.2 A.U.	1.03 A.U.
	Xanthippe	450 days	0.14 A.U.	1.11 A.U.

- Discovery and Charting of Unknown Asteroids and Comets
- Measurements of Solar System and Astronomical Unit to New Accuracy by Factor of > 2.

RADIO ASTRONOMY

- Large Deployed Antenna-Far From Earth Noise

2.5 MARS ORBITER

The Mars orbiter should have all possible commonality with unmanned data gathering vehicles for Earth orbit. This would permit the remotely controlled Earth surveillance vehicles to make a cumulative and direct contribution to the reliability and quality of results of the Mars orbiter vehicle.

Atmospheric orbit-forming operations for the Mars orbiter cannot be checked out effectively in Earth orbit without use of an additional impulse of some 7000 fps to the Earth orbit experimental vehicle. Careful study required of the scaling laws (involving acceleration of gravity, velocity and atmospheric density differences) and dynamics of the vehicles was not performed to determine if such experiments are warranted. Until the mode of Mars orbit formation for this vehicle is determined, the Earth orbit experimental vehicle cannot be finalized. As stated in column 3 of Table I-1, formation of a simulated Mars orbit in Earth orbit will require only a small injection impulse.

Major operational differences in the communications and data readout for the Mars orbiter will distinguish Mars flyby from Earth orbital operations (columns 6 and 7 of Table I-1). Figure I-1 shows the geometry of communications between the Mars orbiter and the spacecraft for both Earth orbit and Mars flyby. As the flyby spacecraft passes beyond Mars it may communicate with the Mars orbiter every orbit. At large distances communication can be accomplished over about 59% of the Mars orbit.

The maximum range at which the Earth orbital spacecraft may communicate with Mars orbiter is about 2700 n.mi. Also, there is no comparable mode of test for the link between the DSIF and the orbiter. The distance is too short in Earth orbit to do other than check out the existence of the link and its proper frequencies. Each DSIF station in the orbital plane (occurring only about once every 15 orbits) covers the orbiter for only about 43° or 12% of the orbit.

In summary, operational checkout of Mars orbiter circular deployment in Earth orbit will be direct and straightforward; complete simulation of Mars parameters including aerodynamic or elliptical orbit formation will be a considerable task.

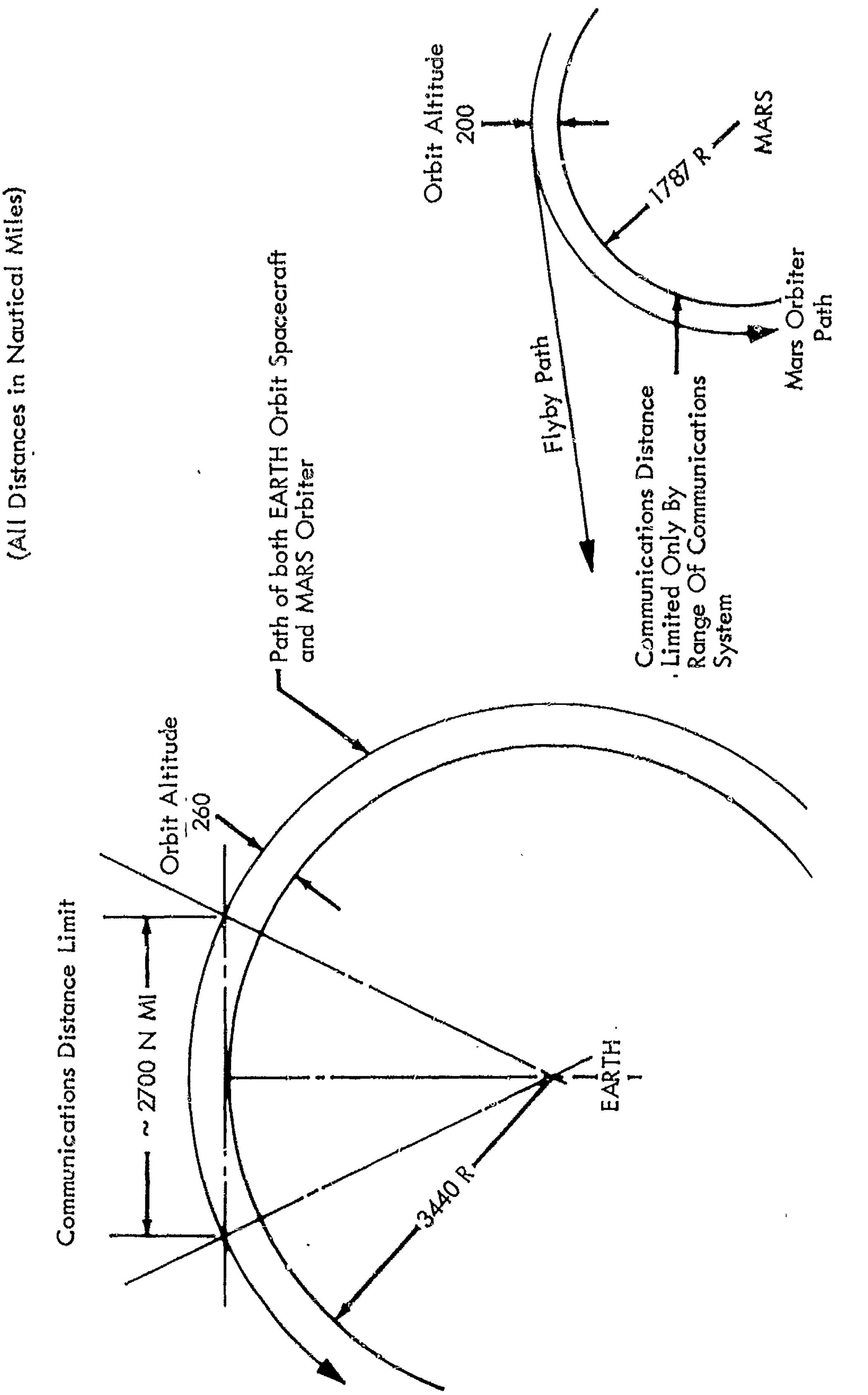


Figure I-1: COMPARISON OF COMMUNICATIONS FOR MARS ORBITER

2.6 MARS SURFACE SAMPLE RETURN MODULE (MSSR)

The MSSR deployment and retrieval may be fully simulated in Earth orbit. However, its operational parameters will be different, and there are no apparent Earth orbital objectives which can be accomplished during this simulation.

Columns 1, 2, 3 and 8 of Table I-1 note that with the appropriate redesign of the landing propulsion system and the heat shield area of the descent vehicle, the operational procedures at deployment will be similar.

Figure I-2 shows that, in some cases, the MSSR landing site selected may be off the flyby trace. Launch for pickup of MSSR payload however, must be from a point in the flyby plane. This may be tested in an Earth orbit simulation by bringing the MSSR back on Spacecraft track near the simulated periapsis. All parameters must be scaled, which will change the timing. The inclination of Earth orbit to equator is about 50°; inclination of Mars flyby trace appears to be 30° to 35° (data not given). This will provide a more abrupt convergence of the Earth orbit with the line of rotation of the MSSR landing site than for the Mars flyby case.

Launching the MSSR payload from Earth will require a larger first stage due to increased gravity in order to lift the return probe and achieve orbit in a single impulse. This is necessary to allow the coast period used for the off-trace landing site. The rendezvous technique of the returning payload in Earth orbit and in the flyby will be identical.

Figure I-3 compared with the Earth sketch of Figure I-1 shows the difference in the geometry of the flyby and Earth orbital tracking and communications problem The Mars flyby view of the landing site is unlimited on approach but extends only about 2500 n.mi. or about 8 minutes beyond before it is obscured by the Mars horizon.

The Earth orbital deployment of the MSSR should monitor the vehicle landing on the orbit previous to the MSSR sample launch and rendezvous in order to allow the sampler to complete its tasks (94.5 min.). This means that the MSSR landing must be displaced from the spacecraft orbit to be in the orbital plane of the pickup orbit. The amount of the lateral displacement will be approximately

$$(60^\circ)\ (23.9\ \text{n.m./deg.})(\sin 50^\circ) = 1100\ \text{n.m.}$$

to the westerly side of the orbit. Monitoring the landing from the spacecraft will be possible if the terrain is smooth.

No Earth orbital objectives have been proposed which can be fulfilled by the Earth orbit tests of the MSSR.

FOLDOUT FRAME

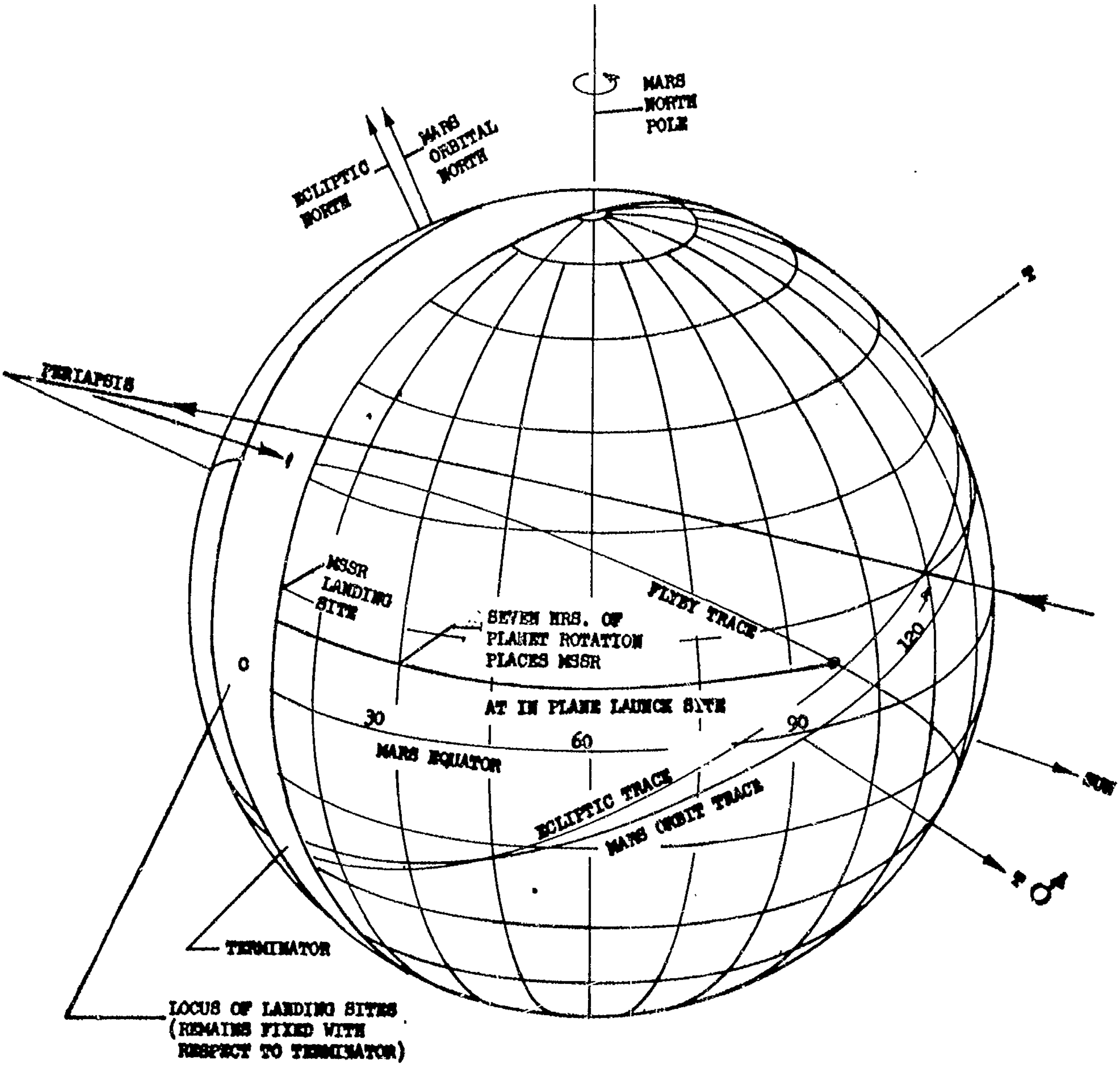
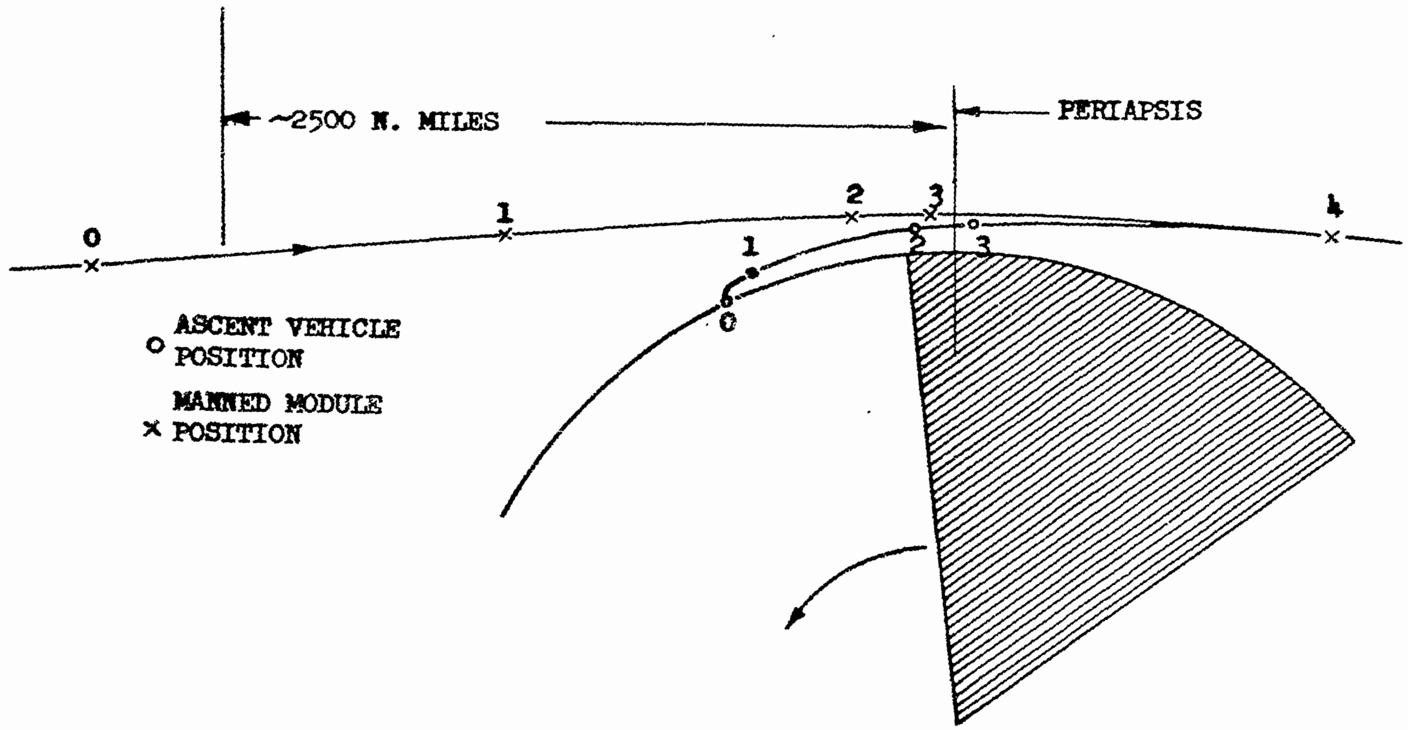


Figure I-2: GEOMETRY OF FLYBY TRAJECTORY



SYMBOL	EVENT	TIME TO ZERO	RELATIVE RANGE
0	ASCENT VEHICLE LIFT OFF	+ 11.5 MIN	2912 N. MILES
1	BURN OUT STAGE 1	+ 6 MIN	1335 N. MILES
2	BURN OUT STAGE 2	+ 1.5 MIN	408 N. MILES
3	IGNITION STAGE 3	+ 0.5 MIN	356 N. MILES
4	BURN OUT STAGE 3	- 5 MIN	0 N. MILES

MSSR

Note: This periapsis altitude scales about 300 N. Miles.

Figure I-3: GEOMETRY OF ASCENT AND PENDEZVOUS MANEUVER

FOLDOUT FRAME

2.7 MARS LANDER

Deployment of the Mars Lander from Earth orbit will involve all the considerations appropriate to the MSSR landing. Propulsion system and heat shield must be scaled. However, this vehicle can be deployed at any time since no rendezvous is required with the spacecraft.

There are no apparently significant Earth orbital objectives which can be fulfilled by deployment of the Mars Lander from Earth orbit.

APPENDIX II

MARCEP ANALYSIS DATA

This appendix contains the data used in the MARCEP (Maintainability and Reliability Cost Effectiveness Program) analysis of the selected configuration. The first part of this appendix contains the MARCEP data sheets which were prepared for each subsystem in the space station. The second part of this appendix presents the results of a typical computer run based on the data contained in the MARCEP data sheets.

MARCEP DATA SHEETS

The MARCEP data sheets organize the subsystem component variables into a format which can be readily punched on computer cards for automated analysis. These data sheets are for the flyby mission. The same components were used for the combined mission but the quantities were different for some subsystems. The data point entries made on these data sheets are explained in the following paragraphs.

a. Nomenclature

The nomenclature describing each component or assembly provides the first entry on the data sheet. In total, this represents an equipment list for the entire space station.

b. Subsystem

Each subsystem was assigned a two-letter identification code:

Subsystem	Code
Communications and Data Management	CD
Crew System	CS
Electrical Power	EP
In-flight Test	IF
Life Support and Environmental Control	LS
Maintenance Equipment	ME
Guidance and Control	SC

c. Component Number

Each component within a given subsystem was assigned an arbitrary number, according to the original sequence when the subsystem listing was established. Once this number was assigned, it was inviolable, and never reused if the item subsequently was deleted as a result of further analysis and evaluation. Any item added after the original sequence had been established was given the next unassigned number regardless of its place in the sequence.

d. Quantity in Basic System

Reflects the number of units required to make up a basic, essentially nonredundant, but completely operable subsystem.

e. Operating Failure Rate (x 10^7)

This is the average number of times the component may be expected to fail in 10,000,000 hours of operation.

f. Dormant Failure Rate (x 10^7)

This is the average number of times a component may be found to be faulty during 10,000,000 nonoperating or on-the-shelf hours.

g. Weight in Pounds

Weight per unit of the line item.

h. Volume in Cubic Centimeters

Volume per unit of the line item.

i. Mean Repair Time

This is the estimated average time in hours required to restore the item to its original operating condition after a failure has occurred. A very serious effort was made to be realistic in this figure, taking into account the space environment, special conditions if appropriate, kinds of tools and other resources required, and inherent difficulty of the function.

j. Repairability Code

Each item was evaluated for its susceptibility to repair and a code number assigned. This code is introduced into the computer program for determining the relative merits of sparing or making redundant. Codes used were as follows:

1) Item cannot be spared or made redundant.
2) Item cannot be repaired or replaced in-orbit.
3) Repair requires external work in spacesuit.
4) Repair is difficult--poor access or other factor.
5) Repair is easily accomplished--shirtsleeve environment.

k. Criticality Code

Each item also was evaluated for the influence it had on the system in the event of a fault. Codes used were:

1) Safety critical - item must operate continuously.

2) Downtime critical - redundancy required.

3) Downtime critical - repair in maximum downtime or less.

4) Repair can be deferred up to 7 days (except RC-2 or RC-3).

5) Repair can be deferred indefinitely.

6) Spares only.

l. Maximum Allowable Downtime

This was the maximum elapsed time in hours which could be tolerated between a failure and restoration of the system or equipment to an operating condition.

m. First Supplementary Component Number

The entry in this column is a separate computer code number for an additional switch, valve, indicator, sensing or monitoring device, or other part required when the line item is added in as standby redundant. Weights, volumes, reliabilities, etc., of these units are mitigating factors to be applied when the line item is added as standby redundant.

n. Second Supplementary Component Number

An additional entry to be used as above when a second such component is required. This may or may not be the same as the first component.

o. Percent Operating Time (x 10)

The proportion of a mission during which the line item is anticipated to be working. Multiplying by ten permits computer mechanization of items with operating times as low as 0.1%.

p. Parallel Lockout

Denies consideration of the line item as a parallel redundant unit. Applies particularly to components associated with EVA, experiments, structure, ducts, and other items for which it is not practicable to provide parallel redundancy.

MARCEP COMPUTER ANALYSIS RESULTS

The following pages present a computer pointout of a typical MARCEP analysis run. The results shown are for a 730 day combined mission to a 0.99 probability of mission success for the space station. Some differences between the data shown here and paragraph 6.0 will be noted. This is due to late changes in some of the subsystems. The column entries are explained in the following paragraphs:

a. Component Number

The component number is the same as shown on the MARCEP data sheets and explained in the first part of this appendix.

b. Basic Component Population

This is the same number as entered in the "Quantity in Basic System" column of the data sheets.

c. Parallel Additions

This indicates the number of components of this type which were added to the system in parallel redundancy to meet the desired reliability objectives. Parallel redundancy is selected by the computer as dictated by the constraints assigned in the MARCEP data sheets (such as: repairability and criticality codes, repair times, allowable downtimes).

d. Standby Additions

This indicates the number of components of this type which were added to the system in standby redundancy to meet the desired reliability objectives. Standby redundancy is selected when constraints are not severe enough to dictate a requirement for parallel redundancy. In order for standby redundancy to be selected, there must be an entry in the first supplementary component number column of the MARCEP data sheet.

e. Spare Additions

This indicates the number of spare components of this type which are required to meet the desired system reliability objectives.

f. Added Weight (Pounds)

The total weight of the parallel, standby, and spare components of this type which were added to the system.

g. Added Cost (Dollars)

This entry not used for this study.

h. Added Volume (Cubic Centimeters)

The total volume of the parallel, standby, and spare components of this type which were added to the system.

i. Added Repair Time (Hours)

The total repair time which would be required if all of the spares added to the system actually had to be installed. It is a product of the spares added and the "Mean Repair Time" in the MARCEP data sheets.

j. Final Reliability

This is the final reliability of this component configuration for the mission duration on which the computer run was made, i.e., it is the probability that the basic component population plus the added parallel redundancy, standby redundancy, and spares will provide for continuous availability of this component function for the complete mission duration.

At the end of each subsystem listing, the total weight added, total volume added, total repair time added, and final reliability for the entire subsystem is printed.

FOLDOUT FRAME

MARCEP DATA SHEET - DOCUMENT INPUT

1975 MARS FLYBY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10⁷)	DORMANT FAILURE RATE (x 10⁷)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT	
COMMUNICATIONS AND DATA																
S-Band Transponder	CD	1	1	250	25	38.0	19600	1.5	5	2	3.0	XX5		1000		
S-Band Power Amp (1350W)		2	1	500	50	60.0	9830	1.0	5	2	3.0	XX 5		100		
S-Band Power Amp (50W)		3	1	270	27	10.0	3580	1.0	5	2	3.0	XX 5		1000		
VHFTransceiver		4	2	30	3	6.75	2750	1.3	5	6				100		
Up-Data Rec'r - Decoder		5	1	50	5	20.0	14650	1.0	5	2	3.0	XX 5		1000		
Antenna (20.5 ft. par.)		6	1	0	0	132.0		4.0	4	5				1000		Eva required
Antenna (8 ft. par.)		7	1	3	1	20.0		4.0	4	5				1000		Eva required
Rend. Radar Transponder		8	1	200	20	10.0	4900	1.0	5	6				1		
Rend. Radar Antenna		9		2	1	4.0		4.0	4	5				1		Eva required
Audio Centers		10	2	20	2	8.0	3015	1.0	5	3	10.0	XX 5		1000		
Audio Cnt. Control Units		11	4	60	6	1.0	820	1.0	5	3	10.0	XX 5		1000		
Mikes and Headsets		12	4	10	1	0.5	111	0.5	5	6				1000		
Premodulation Processor		13	1	60	6	12.0	4950	1.0	5	2	3.0	XX 5		1000		
Central Timing Unit		14	1	30	3	7.0	3970	1.0	5	3	6.0	XX 5		1000		
Parametric Amp.		15	1	200	20	10.0	6560	1.0	5	5				1000		
Signal Cond. Unit		16	1	40	4	50.0	9780	1.0	5	3	6.0			1000		
Data Storage Units		17	4	550	50	40.0	19575	1.0	5	3	6.0			1000		
TV Cameras		18	4	400	40	7.5	1625	1.5	5	5				1000		
VHFDiplexer		19	1	10	1	1.7	990	1.0	5	5				10		
PCM Telemetry Unit		20	1	950	95	90.0	40700	1.0	5	3	6.0			1000		
Video Tape Recorder		21	1	500	50	60.0	19500	2.0	5	5				100		
TV Monitor		22	4	100	10	20.0	9775	1.5	5	5				1000		
Computer		23	1	700	70	100.0	65000	4.0	5	5				1000		
Process Controller	CD	24	1	200	20	150.0	19500	1.0	5	3	6.0			1000		

MARCEP DATA SHEET - DOCUMENT INPUT

MARCEP DATA SHEET - DOCUMENT INPUT

1975 MARS FLYBY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT	
COMMUNICATIONS AND DATA (Continued)																
Printer and Computer Input Keyboard	CD	25	1	200	20	75.0	105000	3.0	5	5				100		
S-Band Rec'r and Mixer		26	1	150	15	7.0	4890	2.0	5	5				100		
S-Band Triplexer		27	1	20	2	5.0	984	2.0	5	5				1000		
Probe Receiver		28	1	120	12	10.0	4890	2.0	5	5				10		
Antenna Booms, Drive		29	2	0	0	50.0		4.0	4	5				100		Eva required
Antenna: VHF		30	2	2	1	2.0		4.0	4	5				100		Eva required
S-Band Modulator		31	1	100	10	5.0	4920	2.0	5	5				100		
S-Band Omni Antenna		32	2	5	1	2.0		2.0	4	5				10		Eva required
C-Band Omni Antenna		33	2	5	1	2.0		2.0	4	5				10		Eva required
C-Band Tranponder		34	1	200	20	23.8	7400	1.0	5	4				10		
Antenna Repair Kit		6	1	6	1	10.0	15000	4.0	4	5				1000		
Antenna Boom Repair Kit	CD	29	1	2	0	7.0	10000	4.0	4	5				100		
TV Pan & Tilt Mechanism	CD	35	4	5	0	7.0	1640	0.5	5	5				1000		

MARCEP DATA SHEET - DOCUMENT INPUT

MARCEP DATA SHEET - DOCUMENT INPUT

MARCEP DATA SHEET - DOCUMENT INPUT

INTERPLANETARY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT
CREW															
Clothing															
Flights Suits	CS	7	24	0	0	.9	2340	.1	5	6				109	
Underwear (Sets)	CS	8	36	0	0	.2	215	.1	5	6				73	
Dryer Locker	CS	9	4	0	0	6.0	226000	.1	5	6				1000	
Exercise Suits	CS	10	24	0	0	.9	1470	.1	5	6				10	
EVA Underwear	CS	11	16	0	0	.9	1470	.1	5	6				10	
Socks	CS	12	112	0	0	.04	198	.1	5	6				2	
Shoes	CS	13	24	0	0	1.1	4720	.5	5	6				109	
Disposal Bags	CS	14	24	0	0	.06	226	.1	5	6				500	
Ready Storage Racks	CS	15	2	0	0	10.4	985000	.1	5	5				1000	
Washer-Dryer Combination	CS	16	1	0	0	100.0	226000	1.0	5	5				46	
Washer-Dryer Repair Kit	CS	16	1	120	6	20.0	7000	1.0	5	5				46	
Crew Quarters															
Sleep Retainer (Mat)	CS	18	4	1	0	6.0	127200	.5	5	5				333	
Sleeper Liner	CS	19	12	1	0	1.0	5570	.1	5	5				333	
Waste Paper Receptacle	CS	20	4	1	0	2.0	10770	.1	5	5				1000	
Desk	CS	21	4	1	0	20.0	354000	.5	5	5				42	
Chair	CS	22	4	1	0	4.0	110500	.5	5	5				666	
Intercom/Warning	CS	23	4	400	40	2.0	2000	2.0	5	6				1000	
Lamp	CS	24	4	6		0.4	850	.2	5	6				666	
Dispensary															
Medical Supplies (Kit)	CS	25	1	0		225.0	623000		4	6				300	
Oxygen Equipment	CS	26	1	20		8.0	56600	2.0	5	3	24.0			10	
Resuscitator	CS	27	1	30		8.0	7080	2.0	5	3	24.0			10	
Aspirator	CS	28	1	30		1.0	7080	2.0	5	3	24.0			10	
Instrument Sterilizer	CS	29	1	10		20.0	56600	2.0	5	3	24.0			10	
Microscope	CS	31	1	5		6.0	28300	3.0	4	5				10	
Blood Analysis Equipment	CS	32	1	5		8.0	13000	2.0	5	3	24.0			10	

MARCEP DATA SHEET - DOCUMENT INPUT

MARCEP DATA SHEET - DOCUMENT INPUT

INTERPLANETARY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT	
CREW																
Exercise and Conditioning																
Lower Body Nega. Press. Boot	CS	33	1	0	0	15.0	425000	1.0	5	4				160		
Tension & Compression Springs	CS	36	1	10	0	55.0	28350	1.0	5	4				160		
LBNP Repair Kit	CS	33	1	500	10	10.0	100000	1.0	5	4				160		
Food Preparation																
Galley Structure	CS	37	1	1	0	20.0	960000	.5	5	5				1		
Oven	CS	38	1	0	0	5.0	28300	1.5	5	6				40	X	
Hot Water System	CS	40	1	0	0	70.0	79500	1.5	5	6				1000		
Cool Water System	CS	41	1	0	0	37.0	79500	1.5	5	6				1000		
Preparation Table	CS	42	1	1	0	2.0	13330	.5	5	5				40		
Disinfectant System	CS	43	1	10	0	2.0	240	1.0	5	6				40		
Trays and Racks	CS	44	4	1	0	4.0	11100	.5	5	5				1		
Table	CS	39	1	1	0	18.0	879000	.5	5	5				1		
Chairs	CS	45	4	1	0	4.0	111000	.5	5	5				1		
Oven Repair Kit	CS	38	1	10	0	2.0	4500	1.5	5	5				40		
Hot Water Repair Kit	CS	40	1	5	0	2.5	5000	1.5	5	5				1000		
Cool Water Repair Kit	CS	41	1	1	0	2.5	5000	1.5	5	5				1000		
Food Storage																
Refrigerator/Freezer Heat Exch	CS	46	1	3	0	13.0	189000	2.0	5	6				150		
Refrigerator/Freezer Motor	CS	47	1	40	0	26.0	35000	1.0	5	6				150		
Refrig/Freezer Compressor	CS	48	1	150	15	26.0	32000	1.5	5	6				150		
Storage Cabinets (Dried Food)	CS	49	146	0	0	3.8	83000	1.0	5	4				1000		Includes 20% Reserve
Refrig/Freezer Compartments	CS	50	76	0	0	5.32	50000	1.0	5	4				1000		Includes 20% Reserve and Medical Storage
Storage Cabinet Repair Kit	CS	49	1	1	0	10.0	3200	1.0	5	5				1000		
Refrig/Freezer Com. Rep. Kit	CS	50	1	3	0	10.0	3200	1.0	5	4				1000		
Stor. Cab. Press. Relief Valv.	CS	49	292	4	2	.15	3	.5	5	4				80		
Stor. Cab. Press. Seals	CS	49	146	10	1	.25	200	.5	5	4				80		
Refrig/Freez. Press Rel. Valv.	CS	50	152	8	2	.15	3	.5	5	4				80		
Refrig/Freezer Press. Seals	CS	50	76	10	2	.25	200	.5	5	4				80		

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INTERPLANETARY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT	
CREW																
Personal Hygiene																
Electric Shaver	CS	53	4	10	1	.5	1420	.5	5	5				13		36500 hrs. wearout life
Nail Clipper	CS	54	4	1	0	.15	142	.1	5	5				13		
Miscellaneous	CS	55	1	1	0	4.0	119000	.1	5	5				13		
Disinfectant Dispenser	CS	56	1	10	0	.2	570	.2	5	6				13		
Collection Container	CS	57	1	1	0	.45	4250	.1	5	5				13		
Personal Kit	CS	58	4	0	0	1.0	2835	.1	5	5				13		
Tooth Brush	CS	59	8	0	0	.02	142	.1	5	5				13		
Shower Housing	CS	60	1	10	0	40.0	1590000	.5	5	6				60		
Recirculating Pump	CS	61	1	100	0	8.0	22600	2.0	5	6				60		
Sponges (Cleaning)	CS	62	4	0	0	.05	2835	.1	5	6				13		Sponge life = 2.33 hr.
Sponge Squeezer Assembly	CS	63	1	1	0	2.5	16400	1.5	5	6				20		
Air-Water Separator	CS	64	1	20	0	2.0	59500	1.0	5	6				20		
Separator Motor	CS	65	1	40	0	1.1	8500	1.0	5	6				20		
Cabinets - Storage	CS	66	1	0	0	10.0	90700	.5	5	5				1000		
Pressure Garments - EVA																
EVA Suit	CS	67	4	0	0	61.0	170000	2.5	5	6				30		
Portable Life Support System	CS	68	4	0	0	64.0	79400	2.5	5	6				3		
Umbilicals and Connectors	CS	69	4	10	0	10.0	71000	.7	5	6				30		
Tethers	CS	70	4	0	0	5.0	14150	.5	5	6				[illegible]		
Manual Locomotion & Restraint	CS	73	1	7	0	20.0	28350	4.8	4	6				100		
Cabinets & Structure	CS	76	4	1	0	27.0	46200	.5	5	5				1000		
EVA Suit Repair Kit	CS	67	4	550	25	61.0	170000	2.5	5	6				30		
PLSS Repair Kit	CS	68	1	900	50	20.0	80000	2.5	5	6				3		
Personal Stowage																
Personal Stowage Locker	CS	86	4	0	0	10.0	113000	.0	5	5				1000		

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INTERPLANETARY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT
CREW															
Crew Recreation Equipment															
Chairs	CS	87	2	0	0	4.0	111000	.5	5	5				200	
Games Kit	CS	88	1	0	0	10.0	70800	.5	5	5				100	
Tape Recorders & Speakers	CS	89	1	0	0	50.0	113000	1.0	5	6				100	
Tape Library	CS	90	1	0	0	40.0	85000	1.0	5	6				100	
Microfilm Viewer	CS	91	2	0	0	4.0	42500	1.0	5	6				100	
Microfilm Library	CS	92	1	0		20.0	76500	1.0	5	6				100	
Film Projector	CS	93	1	0	2	30.0	120000	1.0	5	6				100	
Viewing Screen	CS	94	1	0	0	4.0	14200	.5	5	5				100	
Film Library	CS	95	1	0		60.0	113000	1.0	5	6				100	
Tape Recorder Repair Kit	CS	89	1	300	3	7.0	1400	1.0	5	5				100	
Viewer Repair Kit	CS	91	1	200	3	3.0	1400	1.0	5	5				100	
Projector Repair Kit	CS	93	1	200	3	7.0	1400	1.0	5	5				100	

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1975 MARS FLYBY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL CKOUT
ELECTRICAL POWER															
Solar Cell Panels	EP	1	2	0		1235.0			2	5	0			1000	
Solar Cell Panel	EP	1	1	52		50.0			2	2	0			1000	
SP Zener Regulators	EP	2	2	50		.2	100		2	2	0			1000	
SP Blocking Rectifiers	EP	3	10	10		.2	100		2	2	0			1000	
Battery	EP	4	3	0		345.0	145000	2.5	5	3	0			1000	
Battery Cases	EP	5	3	0		86.3	145000	1.5	4	3	24.0			1000	
Battery Case Maint. Kit	EP	5	1	4		1.0	3000	1.5	4	4	24.0			1000	
Inverters	EP	7	3	33		29.9	23100	1.3	5	2	6.0			1000	
Voltage Regulators	EP	8	2	120		76.8	92800	1.5	5	2	6.0			1000	
Fail Sensors VR	EP	9	3	50		23.1	25100	1.0	4	5	6.0			1000	
Main Contactors	EP	10	8	1		5.2	2050	2.0	5	2	12.0			1000	
Battery Chargers	EP	11	3	30		17.1	8010	1.0	5	4	6.0			1000	
Battery Charge Contactors	EP	12	3	1		6.1	2470	2.0	5	3	6.0			1000	
Battery Charge Fail Sensors	EP	13	3	50		6.1	6600	1.0	4	5	6.0			1000	
Batt. Chg. Reverse Cur. Relay	EP	14	3	5		3.1	5850	1.5	4	3	6.0			1000	
Booster Converter	EP	15	1	100		5.7	16100	1.0	4	3	24.0			1000	
Share Sensor Circuit	EP	16	1	1		.1	100	.5	4	3	24.0			1000	
Buses, Ins. & Housing	EP	17	5	1		5.0	4350	1.5	4	3	24.0			1000	
Fuses, Circuit Brakes	EP	18	100	1		.13	50	.5	5	3	24.0			1000	
Wiring and Connectors	EP	19	50	1		.3	100	3.0	5	3	24.0			1000	
Power Cont. & Module Interc.	EP	20	1	1		25.2	26600	4.0	4	3	24.0			1000	
All Deployment Mechanisms	EP	21	2	0		122.3								7 times	
Launch Shroud	EP	22	1	0		411.2								once	

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1975 MARS FLYBY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT
INFLIGHT TEST															
Displays & Controls															
Switch, 2 Position	IF	1	250	1	1	.06	4	.5	5	3	48.0			1	
Switch, Selector	IF	2	80	5	1	.13	6	.9	5	3	48.0			1	
Caution/Warning Indicators	IF	3	60	6	1	.06	4	.3	5	3	48.0			1	
Indicator Lights (Rectangular)	IF	4	200	6	0	.06	4	.3	5	4				200	
Indicator Lights (Small Diam.)	IF	5	370	6	0	.02	2	.3	5	4				200	
Digital Readout Indicator	IF	6	30	100		.88	13	.7	5	3	24.0			1000	
Temp. Indicator Double Vert. Sc	IF	7	4	40		.33	50	.8	5	3	24.0			1000	
Temp. Indicator Single Vert. Sc	IF	8	6	20		.26	40	.7	5	3	24.0			1000	
Pressure Inc. Double Vert. Sc.	IF	9	8	40		.33	50	.8	5	3	24.0			1000	
Pressure Ind. Single Vert. Sc.	IF	10	12	20		.26	40	.7	5	3	24.0			1000	
Time Indicator, Digital	IF	11	22	100		.26	50	.7	5	3	48.0			1000	
Volt-Amp Meter, Doub. Vert. Sc.	IF	12	6	80		.33	50	.8	5	3	48.0			1000	
Quantity Ind. Doub. Vert. Sc.	IF	13	6	10		.33	50	.8	5	4				1000	
CMG Wheel Speed, Doub. Vert. Sc.	IF	14	4	100		.33	50	.8	5	3	24.0			1000	
Gimbal Angle, Doub. Vert. Sc.	IF	15	3	60		.33	50	.8	5	3	24.0			1000	
Frequency Meter	IF	16	1	100		.26	40	.7	5	3	24.0			1000	
Solar Panel Angle, Doub. Vert.	IF	17	1	60		.33	50	.8	5	3	24.0			1000	
Signal Output, Gyro	IF	18	1	100		.26	50	.8	5	3	24.0			1000	
Radiation Meter	IF	19	1	200		.51	600	.7	5	3	24.0			1000	
Clock, 24 Hour	IF	20	1	50		.11	50	.8	5	3	24.0			1000	
Azimuth Ind. Doub. Vert. Scale	IF	21	1	10		.33	50	.8	5	4				1000	
Elevation Ind. Doub. Vert. Sc.	IF	22	1	50		.33	50	.8	5	4				1000	
Orbital Track Display	IF	23	1	400		1.00	1000	.9	5	3	48.0			1000	

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1975 MARS FLYBY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT
Displays & Controls (Cont'd)															
Flight Director Display	IF	25	1	1510		1.00	1200	.9	5	3	48.0			1000	
Range Indicator, Circular	IF	26	1	30		.44	100	.7	5	3	48.0			1000	
Modulation Level, Vert. Scale	IF	27	1	100		.26	40	.7	5	3	72.0			1000	
Signal Strength (Volts) Vert. Sc	IF	28	1	100		.26	40	.7	5	3	72.0			1000	
RF Power Watts	IF	29	1	200		.26	40	.7	5	3	72.0			1000	
TESTING UNIT															
VTVM	IF	30	1	100	20	10.0	10000	2.5	5	5	96.0			100	
Counter	IF	31	1	50	10	14.8	3200	1.5	5	5	96.0			50	
Oscilloscope	IF	32	1	100	20	13.9	14200	2.5	5	5	96.0			100	
Signal Generator	IF	33	1	200	40	22.0	7000	1.5	5	5	96.0			100	
Voltage Standard	IF	34	1	50	10	10.0	10000	1.2	5	5	96.0			10	
Frequency Standard	IF	35	1	50	10	10.0	10000	1.2	5	5	96.0			10	
Meggar	IF	36	1	100	20	10.0	10000	1.5	5	5	96.0			10	
Manual Test Unit	IF	37	1	200	40	20.0	11400	1.0	5	5	96.0			10	
Test Display & Control Unit	IF	38	1	200	40	12.0	4200	1.5	5	5	96.0			100	
Safety Monitor Unit	IF	39	1	200		9.0	1640	1.0	5	3	24.0			1000	

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1975 MARS FLYBY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT	
EC/LSS																
SuitLoop (100)																
Debris Trap	LS	101	1	45		2.4	6600	1.2	5	3	4.0	XX4		1000		
Canister, Activited Charcoal	LS	102	1	3		1.3	10700	1.0	5	3	4.0	XX4		1000		
Valve, Shutoff Manual	LS	103	4	3		2.0	820	1.0	4	3	4.0			1000		
Compressor, Air Purificatio	LS	104	1	200		5.0	6600	2.0	4	3	4.0	XX3		1000	X	
Valve, Check Air	LS	105	4	3		1.0	820	1.0	4	6	4.0			1000		
Valve, Shutoff Manual	LS	106	1	3		1.3	820	1.5	4	6	4.0			1000		
Catalytic Oxidizer	LS	107	1	280		16.0	37800	2.0	4	6	4.0			1000		
Canister, Chemisorbent	LS	108	1	3		1.3	10700	2.0	4	6	4.0			1000		
Valve, Shutoff Automatic	LS	109	2	100	2	3.5	1300	1.0	4	6				10		Required only for Decomposition
Connector, Suit	LS	110	8	6	0	.4	650	1.0	4	6				10		Only during Emergency
Compressor, Emergency	LS	111	1	200	4	5.0	6600	2.0	4	2	.1	XX2	XX3	10	X	Only during Emergency
Canister, LiOH	LS	112	1	45	1	1.0	4300	.5	5	2	.1	XX4		10		
Humidity Control Hx	LS	113	1	3		15.0	98500	2.0	4	3	4.0	XX4		1000		
Separator, Water	LS	114	1	100		9.5	24600	1.5	4	3	4.0	XX3		1000	X	
Ducts and Plumbing	LS	115	1	0		40.0								1000		
CO_2 Removal (200)																
Canister, Silica Gel	LS	201	2	20		16.0	15600	6.0	4	3	4.0	XX4		1000		
Canister, Zeolite	LS	202	2	20		19.0	17900	6.0	4	3	4.0	XX4		1000		
Valve, Diverter Dual	LS	203	2	20		2.6	525	1.5	4	3	4.0	XX9		1000		
Valve, Diverter	LS	204	2	20		1.0	262	1.5	4	3	4.0	XX9		1000		
Sensor, Relative Humidity	LS	205	1	300		1.0	100	.5	5	6	4.0			1000		
Timer	LS	207	1	30		4.0	252	1.5	5	6	4.0			1000		
Valve, Check Air	LS	208	1	3		.5	213	1.0	4	3	4.0	XX8		1000	X	
Compressor, CO_2 Removal	LS	209	1	150		5.5	1230	2.0	4	3	4.0	XX2		1000		
Valve Diverter	LS	210	2	20		1.0	525	1.5	4	3	4.0	XX7		1000		
Pump, CO_2	LS	211	1	200		15.0	2800	2.0	4	4	24.0			1000		
Exhaust Coolant Hx	LS	213	1	3		5.0	3500	1.5	4	3	4.0	XX3		1000		
Plumbing and Instl.	LS	215	1	0		15.0			4	5				1000		

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1975 MARS FLYBY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT	
EC/LSS																
Water Management (300)																
Separator, Water	LS	301	4	1		6.5	8200	1.5	4	3	12.0	XX4		75		
Valve, Check Water	LS	302	18	3		.1	50	1.0	5	3	12.0	XX9		75		
Filter, Water	LS	303	2	3		1.5	1640	.5	5	3	12.0	XX4		75		
Pump, Reverse Osmosis	LS	304	2	200	4	24.0	14800	3.0	4	3	12.0	XX2		75		
Tank, Water	LS	305	2	1		16.0	100000	3.0	4	3	12.0			100		
Heater	LS	306	6	5		2.0	820	1.0	5	3	12.0	XX7		75		
Sterilizer	LS	307	5	10		10.0	28300	3.0	4	3	12.0			100		
Vapor Compressor Unit	LS	308	2	200	4	46.7	25000	6.0	4	3	12.0	XX4		75		
Pump	LS	309	4	200	4	1.0	690	1.0	4	3	12.0			75		
Tank, Water	LS	310	-	-		8.0	51000	3.0	4	3	12.0	XX3		100		
Sensor, Ph	LS	311	-	300		1.0	100	1.0	4	3	12.0			100		
Canister, Charcoal	LS	312	4	3		2.0	2050	1.0	5	3	12.0			100		
Urinal & Commode Assy	LS	316	1	0		31.15	164000	1.0	5	3	12.0			10		
Disconnect	LS	318	6	1		.2	82	1.0	5	3	12.0			75		
Filter, Bacterial	LS	319	2	10		.5	230	.5	5	3	12.0			100		
Valve, Motor Act	LS	320	2	60	1	.5	820	1.0	5	3	12.0			75		
Sensor, Conductivity	LS	321	2	100		.4	250	.5	5	3	12.0			100		
Valve, Shutoff	LS	322	9	3		.4	330	1.0	5	3	12.0			75		Inc. 8 valves for water supply
Vapor Comp.,Frame,Pipes Sup	LS	323	2	0		18.4	28300	1.0	5	3	12.0			100		
Reverse Osmosis Frame,Pipes	LS	324	2	0		16.6	28300	1.0	5	3	12.0			1000		
Tank, Water Supply	LS	325	2	1		38.2	345000	1.0	5	3	12.0			1000		Water stored 382 $\frac{LBS}{Tank}$
Tank, Installation	LS	326	2	0		42.0	28400	1.0	5	3	12.0			1000		
Plumbing and Instl.	LS	327	1	0		50.0		1.0	5	3	12.0			1000		

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1975 MARS FLYBY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT	
EC/LSS																
Thermal Control (400)																
Pump, Freon E-3	LS	401	1	200		5.0	1640	1.5	4	2	.2	XX4	XX3	1000	X	
Valve, Check	LS	402	4	3		.1	82	1.0	4	2	.2	XX5		1000		
Primary Cooler Hx	LS	403	1	3		13.0	21300	1.0	4	2	.2	XX7		1000		
Radiator	LS	404	1	0		430.0		3.5	3	1	.2			1000		
Regenerative Hex Exch.	LS	405	1	3		15.0	24600	1.0	3	2	.2	XX7		1000		
Valve, Cabin Temp. Control	LS	407	1	100		1.0	158	1.0	4	3	2.0	XX7		1000		
Valve, Diverter	LS	408	2	20		1.0	158	1.0	4	3	2.0	XX5		1000		
Regenerative Hx, Cabin	LS	409	1	4		7.0	11500	1.0	4	3	4.0	XX7		1000		
Valve, Manual Shutoff	LS	413	4	3		.4	32	1.0	4	3	.2	XX5		1000		
Reservoir E-3	LS	414	1	1		170.0	65600	1.0	4	2	.2	XX3		1000		Includes 150 lb. E-3
Screen Cabin Air	LS	415	2	1		.3	500	.5	5	6	10.0			1000		
Fan, Cabin Air	LS	416	2	20		8.0	18500	1.0	5	3	2.0	XX5		1000	X	
Valve, Check Air	LS	417	2	3		2.0	6250	1.0	5	3	2.0	XX4		1000		
Heat Exch. Cabin	LS	418	2	3		15.0	28800	1.0	4	3	2.0	XX7		1000		
Switch, Pressure	LS	419	2	100		.7	158	1.0	5	3	2.0	XX4		1000		
Cabin Ducting & Instl.	LS	420	1	0		25.0	49000	1.0	5	3	2.0			1000		
Plumbing & Instl.	LS	421	1	0		50.0	33000	1.0	5	3	1.0			1000		
Transport Fluid	LS	422	1	0		166.5								1000		
Pump, Water	LS	410	1	200		2.3	1230	1.0	4	3	.2	XX7	XX3	1000	X	
Disconnect, Ground Service	LS	412	2	1		.4	158	2.0	4	3	.2			1000		
Valve, Diverter	LS	406	1	20		1.0	158	1.0	4	3	2.0	XX5		1000		
Reservoir, Water	LS	423	2	1		102.0	41800	1.0	4	4				1000		Includes 92 lb. H_2O/Tank

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1975 MARS FLYBY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT	
EC/LSS																
Atmos, Supply (500)																
Tank, Cryogenic O_2	LS	516	6	1		1850.0	920000	3.5	2	1		XX6	XX10	1000		Includes 1645 lbs O_2/tank
Valve, Mod Elect	LS	509	2	60		1.5	525	1.5	5	4				1000		
Control, Atmos	LS	511	1	100		3.0	1230	2.0	5	6				1000		
Valve, O_2 Mask	LS	512	4	30		.5	525	2.0	5	6				1000		
Valve, Cabin Relief & Dump	LS	513	1	25		5.0	1640	2.0	2	1				1000		
PLSS Disconnect & Valve	LS	514	1	2		.6	200	.5	5	3	12.0			1000		
Valve, Hatch Press Equal	LS	515	1	1		1.8	350	.5	5	3	12.0			1000		
Tank, Cryogenic N_2	LS	516	3	1		1345.0	920000		2	1				1000		Includes 1150 lbs N_2/tank
Valve, Shutoff	LS	517	9	40		.65	150	3.0	4	2	12.0			1000		
Valve, Check	LS	518	9	3		.2	150	3.0	4	2	12.0			1000		
Valve, Vent	LS	519	9	25		.1	150	2.5	4	2	12.0			1000		
Valve, Relief	LS	520	9	25		1.35	150	2.5	4	2	12.0			1000		
Switch, Pressure	LS	521	9	100		1.0	150	2.5	4	2	12.0			1000		
Transducer, Pressure	LS	522	9	200		.3	130	2.0	4	2	12.0			1000		
Disconnect	LS	523	9	9		.4	35	2.0	4	6				1000		
Valve Supports & Mounts	LS	524	9	0		1.3	200		4	4				1000		
Plumbing	LS	525	1	0		100.0	50000	3.0	4	3	4.0			1000		
Tank Supports	LS	526	9	0		18.0	15000	3.0	4	3	4.0			1000		
Valve, Manual S.O.	LS	504	2	1		1.0	500	1.0	5	4	24.0			1000		
Valve, Pressure Regulator	LS	528	2	100		1.5	1500	1.0	5	3	4.0			1000		

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1975 MARS FLYBY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT
MAINTENANCE EQUIPMENT															
Standard Tool Kit	ME	1	1	0		[illegible]	42000								
Vacuum System		2	1	143	0	3.0	3000	2.0	5	5				10	
Special Tools															
Space Power Tool Kit		3	1	100	0	8.0	12159	2.0	4	5				1	
Electron [illegible]		4	1	35000	[illegible]	[illegible]	[illegible]	3.0	4	5				1	
Stemfeo T[illegible]		5	1	50	0	7.0	8100	2.0	4	5				1	
Leak Detection Equipment		6	1	[illegible]00	[illegible]	[illegible]	7000	2.0	4	5					
Temperature Measuring Device		7	1	20	0	[illegible]	[illegible]00	2.0	4	5				1	
Pressure Measuring Device		8	1	20	[illegible]	[illegible]	[illegible]000	[illegible]	4	5				1	
Water Test Kit		9	1	0	[illegible]	[illegible]	800	2.0	4	[illegible]				1	
Battery Test Kit		10	1	0	0	[illegible]	[illegible]00	2.0	4	5				1	
Electrical Repair Kit		11	1	0	0	[illegible]	[illegible]500	[illegible]	4	5				1	
Lubrication Kit		12	1	0	0	[illegible]	[illegible]	2.0	4	5				1	
Fabric Repair Kit		13	1	0	0	[illegible]	3000	2.0	[illegible]	5				1	
Air Flow Meter	ME	14	1	50	[illegible]	[illegible]	500	2.0	4	5				1	

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1975 MARS FLYBY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT	
MIDCOURSE PROPULSION MODULE																
Helium Tank (fuel)	PP	1	2	1		43.85	68000	4.0	4	2	24.0	XX3		150		Includes 5.15 lbs Helium/Tank
Helium Squib Valves (NC)		2	12	15	1	.25	57	4.0	4	[illegible]	24.0	XX3		1		NC - Normally Closed
Helium Squib Valves (NO)		3	12	15	1	.25	57	4.0	4	[illegible]	24.0			1		NO - Normally Open
Helium Filter		4	2	1		.25	142	2.0	4	3	24.0			1		
Helium Pressure Regulator		5	2	6		1.5	283	2.0	4	2	24.0			1		
Helium Check Valve		6	2	1		.2	57	2.0	4	3	24.0			1		
Helium Solenoid Shutoff Valve		7	2	40		.2	142	8.0	4	3	24.0			150		Normally Closed
Helium Burst Disk		8	2	1		.25	57	8.0	4	2	24.0			1		
Helium Filter		9	2	1		.25	142	8.0	4	3	24.0			1		
Helium Pressure Relief Valve		10	2	4		.8	142	8.0	4	3	24.0			1		
Fuel Tank		11	2	1		2125.0	3350000	-	2	2	24.0	XX3		150		Includes 1833 lbs fuel/tank
Fuel Tank Vent Valve		12	2	4		.5	57	-	2	2	24.0			75		Normally Closed
Fuel Prevalve (Solenoid)		13	2	40		3.0	1420	-	2	2	24.0			1		Normally Closed
Fuel Supply Line		14	2	1		10.0	6200	8.0	4	3	24.0			1	X	
Fuel Line Bleed Orifice		15	2	10		.05	28	2.0	4	3	24.0			1		
Fuel Line Bleed Valve		16	2	25		.1	57	2.0	4	3	24.0			1		Normally Open
Fuel Vent Heat Exchanger		17	2	3		5.0	250	-	2	2	24.0	XX3		75		
P&W RL10A-3-3H Rocket Engine		18	2	76		295.0	1020000	8.0	4	3	24.0	XX6		1		Pump-fed, Gimballed
Helium Supply Line		21	2	1		1.0	280	4.0	4	3	24.0			150		
Interconnect Squib Valve (NC)		22	2	15		.25	57	2.0	4	2	24.0			1		Normally Closed
Helium Interconnect Line	PP	23	2	1		.1	142	2.0	4	3	24.0			150		

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1975 MARS FLYBY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT	
MIDCOURSE PROPULSION MODULE																
Helium Tank (Oxidizer)	PP	24	2	1		87.5	144200	4.0	4	2	24.0	XX3		150		
Helium Squib Valves (NC)		25	12	15		.25	57	4.0	4	2	24.0	XX3		1		Normally Closed
Helium Squib Valves (NO)		26	12	15		.25	57	4.0	4	2	24.0			1		Normally Open
Helium Filter		27	2	1		.25	142	2.0	4	3	24.0			1		
Helium pressure Regulator		28	2	6		1.5	283	2.0	4	2	24.0			1		
Helium Check Valve		29	2	1		.2	57	2.0	4	3	24.0			1		
Helium Solenoid Shutoff Valve		30	2	40		.2	142	8.0	4	3	24.0			150		Normally Closed
Helium Burst Disk		31	2	1		.25	57	8.0	4	2	24.0			1		
Helium Filter		32	2	1		.25	142	8.0	4	3	24.0			1		
Helium Pressure Relief Valve		33	2	4		.8	142	8.0	4	3	24.0			1		
Oxidizer Tank		34	4	1		5523.0	2830000	-	2	2	24.0	XX3		150		Includes 5257 lbs oxidizer/tank
Oxidizer Tank Vent Valve		35	2	4		.5	57	-	2	2	24.0			75		Normally Closed
Oxidizer Prevalve (solenoid)		36	2	40		3.0	566	-	2	2	24.0			1		Normally Closed
Oxidizer Supply Line		37	2	1		10.0	6220	8.0	4	3	24.0			1		
Oxidizer Line Bleed Orifice		38	2	10		.05	28	2.0	4	3	24.0			1		
Oxidizer Line Bleed Valve		39	2	25		.1	57	2.0	4	3	24.0			1		Normally Open
Oxidizer Vent Heat X-changer		40	2	3		5.0	283	-	2	2	24.0	XX3		75		
Helium Supply Lines	PP	43	2	1		1.0	283	4.0	4	3	24.0			150		

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1975 MARS FLYBY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT	
FLIGHT CONTROL																
IMAG Package	SC	1	1	1430	50	20.4	8600	1.0	5	4				250		Wearout 15 K hrs.
SCS Control Elec. Assy.		2	1	200		13.9	10000	.5	4	3	6.0			1000		
TVC Servo Amplifier		3	1	200	10	10.8	7000	.5	4	4				10		
Display Elec. Assy.		4	1	200		24.1	12500	.5	4	4				1000		
Reaction & Prop. Driver Assy.		5	1	200		18.6	13200	.5	4	4				1000		
Gyro Display Coupler		6	1	200		23.4	28000	.5	4	4				1000		
Flight Director Att. Indicator		7	1	1000		9.0	5800	1.0	5	5				1000		
Gimbal Position Indicator		8	1	1000	50	2.7	1500	1.0	5	4				10		
Rotation Controller		9	1	100	5	7.2	2200	.5	5	5				50		
Attitude Set Control		10	1	1000	50	3.6	1900	1.0	5	4				10		
Horizon Sensor Package		11	2	500		5.0	2800	.1	2	2	24.0			100		
Sun Sensor Package		12	2	10		.6	600	.1	2	2	24.0			1000		
Star Tracker		13	1	67	3	7.0	15000	.1	2	2	24.0			500		
2-DOF CMG Structure		15	6	10		90.0	231000	2.0	4	4				1000		
Bearings, Rotor		16	12	150		1.0	850	3.0	4	4				1000		Wearout 20 K hrs.
Bearings, Gimbal		17	24	02		1.0	850	3.0	4	4				1000		
Torquer Assy., Gimbal		18	12	15		12.0	3500	2.0	4	4				1000		
Pickoff, Gimbal		19	12	05		1.0	500	.5	4	4				1000		
Spin Motor/Rotor Assy.		20	6	26		58.0	50000	4.0	4	4				1000		
CMG Control Elec. Assy.		21	1	200		24.0	12500	.5	4	4				1000		
Inverter Elec. Assy.	SC	22	1	300		57.0	20000	.5	4	4				1000		

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1975 MARS FLYBY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT	
<u>FLIGHT CONTROL</u> (Continued)																
Torquer Elec. Assy.	SC	23	4	140		10.0	2500	.5	4	4				1000		
Reaction Jet Plus Pitch		24	1	20		5.6	7400	4.1	2	2	.2			1000		25 K cycles .965 P success
Minus Pitch		25	1	20		5.6	7400	4.1	2	2	.2			1000		"
Plus Roll		26	2	20		5.6	7400	4.1	2	2	.2			1000		"
Minus Roll		27	2	20		5.6	7400	4.1	2	2	.2			1000		"
RCJ Propellant Storage, Regulation & Distribution																
Regulators		29	2	40		1.5	2200	4.0	2	2	6.0			1000		
Check Valves		30	4	10		.6	900	4.0	2	2	6.0			1000		
Relief Valves		31	4	10		.6	900	4.0	2	2	6.0			1000		
Fill & Drain, Liquid		32	4	10		1.0	1200	4.0	2	2	6.0			1000		
Fill & Drain, Gas		33	2	10		1.0	1200	4.0	2	2	6.0			1000		
Shutoff Valves		34	2	30		1.0	1500	4.0	2	2	6.0			1000		
Fuel Tanks W/Bladders and Quantity Gages		35	4	1		226.0	67000	4.0	2	2	6.0			1000		Includes 200 lbs fuel/tank
Oxidizer Tanks W/Bladders and Quantity Gages		36	4	1		451.0	67000	4.0	2	2	6.0			1000		Includes 425 lbs oxidizer/tank
Line Systems	SC	37	2	1		4.0	6000	4.0	2	2	6.0			1000		

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1975 MARS FLYBY	SUB-SYSTEM	COMPONENT NUMBER	QUANTITY IN BASIC SYSTEM	OPERATING FAILURE RATE (x 10^7)	DORMANT FAILURE RATE (x 10^7)	WEIGHT IN POUNDS	VOLUME IN CUBIC CM	MEAN REPAIR TIME	REPAIRABILITY CODE	CRITICALITY CODE	MAXIMUM ALLOWABLE DOWNTIME	FIRST SUPPLEMENTARY COMPONENT NUMBER	SECOND SUPPLEMENTARY COMPONENT NUMBER	PERCENT OPERATING TIME (x 10)	PARALLEL LOCKOUT
FLIGHT CONTROL (con't)															
Inertial Measurement Unit															
Inertial Platform	SC	39	1	300		73.0	141000	4.0	4	3	12.0			1000	
Platform Electronics	SC	40	3	150		3.0	3000	1.0	5	3	12.0			1000	
Fine Alignment Electronics	SC	41	3	150		3.0	3000	1.0	5	3	12.0			1000	
Accelerometer Electronics	SC	42	3	100		3.0	3000	1.0	5	3	12.0			1000	
Optical System	SC	43	1	200		62.0	80000	2.0	4	4				50	

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SUBSYSTEM CD - COMMUNICATIONS AND DATA MANAGEMENT

COMPONENT NUMBER	BASIC COMPONENT POPULATION	PARALLEL ADDITIONS	STANDBY ADDITIONS	SPARE ADDITIONS	ADDED WEIGHT (POUNDS)	ADDED COST (DOLLARS)	ADDED VOLUME (CENTIMETERS)	ADDED REPAIR TIME (HOURS)	FINAL RELIABILITY
CD 1	1	1	0	1	16.00	0	9200	1.0	.9999996
CD 1	4	4	0	20	84.00	0	36000	20.0	.9999573
CD 1	2	2	0	9	55.00	0	27500	9.0	.9999805
CD 1	1	0	1	2	18.22	0	12640	2.0	.9999967
CD 2	1	1	0	0	12.00	0	2830	.0	.9999890
CD 2	2	2	0	5	49.00	0	6300	5.0	.9999529
CD 2	2	2	0	4	57.00	0	6600	4.0	.9999485
CD 2	3	3	0	9	60.00	0	12000	9.0	.9999557
CD 3	1	0	1	4	50.22	0	18540	4.0	.9999896
CD 4	2	0	0	2	13.50	0	5500	2.6	.9999987
CD 5	1	0	1	2	60.22	0	44590	2.0	.9999977
CD 6	1	0	0	0	.00	0	0	.0	1.0000000
CD 6	1	1	0	1	20.00	0	30000	-.0	.9999992
CD 7	1	0	0	1	20.00	0	0	4.0	.9999862
CD 8	1	0	0	2	20.00	0	9800	3.0	.9999928
CD 9	1	0	0	1	4.00	0	0	4.0	.9999985
CD 10	3	0	0	3	24.00	0	9145	3.0	.9999953
CD 11	8	0	0	7	7.00	0	5740	7.0	.9999970
CD 12	8	0	0	4	2.00	0	444	2.0	.9999996
CD 13	1	0	1	2	36.22	0	15490	3.0	.9999953
CD 14	1	0	0	2	14.00	0	7940	2.0	.9999767
CD 15	1	0	0	4	40.00	0	26240	5.2	.9999671
CD 16	1	0	0	2	100.00	0	19560	2.0	.9999456
CD 17	4	0	0	1	10.00	0	5500	-.0	.9999756
CD 17	24	0	0	7	11.90	0	5810	-.0	.9999941
CD 17	24	0	0	6	10.20	0	4020	-.0	.9999954
CD 17	12	0	0	10	33.00	0	16700	-.0	.9999901
CD 18	6	0	0	14	105.00	0	22750	7.0	.9999650
CD 19	1	0	0	1	1.70	0	990	1.0	.9999982
CD 20	1	0	0	1	20.00	0	10000	10.0	.9999985
CD 20	10	0	0	6	24.00	0	10200	60.0	.9999986
CD 20	10	0	0	5	15.00	0	7000	50.0	.9999989
CD 21	1	0	0	1	15.00	0	6000	-.0	1.0000000
CD 21	5	0	0	2	4.00	0	2000	-.0	.9999940
CD 21	6	0	0	3	7.50	0	3300	-.0	.9999995
CD 21	8	0	0	3	7.50	0	2250	-.0	.9999987
CD 22	6	0	0	2	10.00	0	4000	-.0	.9999998
CD 22	24	0	0	6	6.60	0	4500	-.0	.9999997
CD 22	18	0	0	4	7.00	0	2400	-.0	.9999964

SUBSYSTEM CD - PAGE 2

COMPONENT NUMBER	BASIC COMPONENT POPULATION	PARALLEL ADDITIONS	STANDBY ADDITIONS	SPARE ADDITIONS	ADDED WEIGHT (POUNDS)	ADDED COST (DOLLARS)	ADDED VOLUME (CENTIMETERS)	ADDED REPAIR TIME (HOURS)	FINAL RELIABILITY
CD 22	6	0	0	5	25.00	0	15000	-.0	.9999946
CD 23	1	0	0	2	40.00	0	30000	-.0	.9999991
CD 23	6	0	0	5	20.00	0	10000	-.0	.9999989
CD 23	6	0	0	6	18.00	0	12000	-.0	.9999989
CD 23	9	0	0	5	20.00	0	15000	-.0	.9999963
CD 24	1	0	0	1	30.00	0	5000	10.0	.9999985
CD 24	4	0	0	4	5.20	0	4000	40.0	.9999971
CD 24	6	0	0	3	15.90	0	2100	30.0	.9999826
CD 24	6	0	0	4	10.60	0	3200	40.0	.9999996
CD 25	1	0	0	1	25.00	0	35000	-.0	.9999996
CD 25	1	0	0	1	15.00	0	20000	-.0	.9999966
CD 25	2	0	0	2	16.00	0	30000	-.0	.9999994
CD 25	3	0	0	2	12.00	0	20000	-.0	.9999994
CD 26	1	0	0	2	14.00	0	9750	4.0	.9999962
CD 27	1	0	0	2	10.00	0	1968	4.0	.9999930
CD 28	1	0	0	2	20.00	0	9780	4.0	.9999980
CD 27	2	0	0	0	.00	0	0	.0	1.0000000
CD 29	1	1	0	0	7.00	0	10000	.0	.9999999
CD 30	2	0	0	2	4.60	0	0	8.0	1.0000000
CD 31	1	0	0	2	10.00	0	9840	4.0	.9999989
CD 32	2	0	0	1	2.00	0	0	2.5	.9999934
CD 33	1	0	0	2	4.00	0	9840	5.0	.9999989
CD 34	1	0	0	2	47.60	0	14600	3.0	.9999910
CD 35	6	0	0	2	14.00	0	3280	2.0	.9999767
TOTALS:					1436.28	0	683967	378.3	.9994285

SUBSYSTEM CS - CREW SYSTEM

COMPONENT NUMBER	BASIC COMPONENT POPULATION	PARALLEL ADDITIONS	STANDBY ADDITIONS	SPARE ADDITIONS	ADDED WEIGHT (POUNDS)	ADDED COST (DOLLARS)	ADDED VOLUME (CENTIMETERS)	ADDED REPAIR TIME (HOURS)	FINAL RELIABILITY
CS 7	24	0	0	0	.00	0	0	.0	1.0000000
CS 8	36	0	0	[illegible]	.00	0	0	.0	1.0000000
CS 9	4	0	0	0	.00	0	0	.0	1.0000000
CS 10	24	0	0	0	.00	0	0	.0	1.0000000
CS 11	16	0	0	0	.00	0	0	.0	1.0000000
CS 12	112	0	0	0	.00	0	0	.0	1.0000000
CS 13	24	0	0	0	.00	0	0	.0	1.0000000
CS 14	24	0	0	0	.00	0	3	.0	1.0000000
CS 15	2	0	0	0	.00	0	0	.0	1.0000000
CS 16	1	0	0	0	.00	0	0	.0	1.0000000
CS 16	1	0	0	2	40.00	0	14000	2.0	.9999987
CS 18	4	0	0	0	.00	0	0	.0	1.0000000
CS 19	2	0	0	0	.00	0	0	.0	1.0000000
CS 20	4	0	0	0	.00	0	0	.0	1.0000000
CS 21	4	0	0	0	.00	0	0	.0	1.0000000
CS 22	4	0	0	0	.00	0	0	.0	1.0000000
CS 23	4	0	0	12	24.00	0	24000	24.0	.9999920
CS 24	4	0	0	3	1.20	0	2550	.6	1.0000000
CS 25	1	0	0	0	.00	0	0	.0	1.0000000
CS 26	1	0	0	1	8.00	0	56600	2.0	.9999999
CS 27	1	0	0	1	8.00	0	7080	2.0	.9999999
CS 28	1	0	0	1	1.00	0	7080	2.0	.9999999
CS 29	1	0	0	1	20.00	0	55600	2.0	1.0000000
CS 31	1	0	0	1	6.00	0	28300	3.0	1.0000000
CS 32	1	0	0	1	8.00	0	13000	2.0	1.0000000
CS 33	1	0	0	0	.00	0	0	.0	1.0000000
CS 33	2	0	0	4	40.00	0	400000	4.0	.9999616
CS 35	2	0	0	1	55.00	0	28350	1.0	.9999843
CS 37	2	0	0	0	.00	0	0	.0	.9999965
CS 38	2	0	0	0	.00	0	0	.0	1.0000000
CS 38	2	0	0	1	2.00	0	4500	1.5	.9999990
CS 39	2	0	0	0	.00	0	0	.0	.9999965
CS 40	2	0	0	0	.00	0	0	.0	1.0000000
CS 40	2	0	0	2	5.00	0	10000	3.0	.9999991
CS 41	2	0	0	0	.00	0	0	.0	1.0000000
CS 41	2	0	0	1	2.50	0	5000	1.5	.9999939
CS 42	2	0	0	1	2.00	0	13380	.5	1.0000000
CS 43	2	0	0	1	2.00	0	240	1.0	.9999990
CS 44	8	0	0	0	.00	0	0	.0	.9999860

SUBSYSTEM CS . PAGE 2

COMPONENT NUMBER	BASIC COMPONENT POPULATION	PARALLEL ADDITIONS	STANDBY ADDITIONS	SPARE ADDITIONS	ADDED WEIGHT (POUNDS)	ADDED COST (DOLLARS)	ADDED VOLUME (CENTIMETERS)	ADDED REPAIR TIME (HOURS)	FINAL RELIABILITY
CS 45	8	0	0	0	.00	0	0	.0	.9999860
CS 46	2	0	0	1	13.00	0	189000	2.0	.9999968
CS 47	2	0	0	2	52.00	0	70000	2.0	.9999985
CS 48	2	0	0	3	78.00	0	96000	4.5	.9999912
CS 49	2	0	0	1	10.00	0	3200	1.0	.9999939
CS 49	292	0	0	0	.00	0	0	.0	1.0000000
CS 49	584	0	0	12	1.80	0	36	6.0	.9999994
CS 49	292	0	0	8	2.00	0	1600	4.0	.9999996
CS 50	2	0	0	2	20.00	0	6400	2.0	.9999998
CS 50	152	0	0	0	.00	0	0	.0	1.0000000
CS 50	304	0	0	10	1.50	0	32	5.0	.9999991
CS 50	152	0	0	6	1.50	0	1200	3.0	.9999998
CS 53	8	0	0	2	1.00	0	2840	1.0	.9999995
CS 54	8	0	0	1	.15	0	142	.1	1.0000000
CS 55	2	0	0	1	4.00	0	119000	.1	1.0000000
CS 56	2	0	0	1	.20	0	573	.2	.9999999
CS 57	2	0	0	1	.45	0	4250	.1	1.0000000
CS 58	8	0	0	0	.00	0	0	.0	1.0000000
CS 59	16	0	0	0	.00	0	0	.0	1.0000000
CS 60	2	0	0	0	.00	0	0	.0	1.0000000
CS 60	2	0	0	1	5.00	0	5000	.5	.9999973
CS 61	2	0	0	2	16.00	0	45200	4.0	.9999965
CS 62	8	0	0	0	.00	0	0	.0	1.0000000
CS 63	2	0	0	1	2.50	0	16400	1.5	1.0000000
CS 64	2	0	0	1	2.00	0	59500	1.0	.9999990
CS 65	2	0	0	2	2.22	0	17000	2.0	1.0000000
CS 66	2	0	0	0	.00	0	0	.0	1.0000000
CS 67	8	0	0	0	.00	0	0	.0	1.0000000
CS 67	8	0	0	4	244.00	0	680000	12.5	.9999704
CS 68	8	0	0	0	.00	0	0	.0	1.0000000
CS 68	2	0	0	3	60.00	0	240000	7.5	.9999586
CS 69	8	0	0	2	20.00	0	142000	1.4	.9999991
CS 70	8	0	0	0	.00	0	0	.0	1.0000000
CS 73	2	0	0	1	20.00	0	28350	4.8	.9999970
CS 76	8	0	0	2	27.00	0	46200	1.0	.9999995
CS 86	8	0	0	0	.00	0	0	.0	1.0000000
CS 87	4	0	0	0	.00	0	0	.0	1.0000000
CS 88	2	0	0	0	.00	0	0	.0	1.0000000
CS 89	2	0	0	0	.00	0	0	.0	1.0000000

SUBSYSTEM CS PAGE 3

COMPONENT NUMBER	BASIC COMPONENT POPULATION	PARALLEL ADDITIONS	STANDBY ADDITIONS	SPARE ADDITIONS	ADDED WEIGHT (POUNDS)	ADDED COST (DOLLARS)	ADDED VOLUME (CENTIMETERS)	ADDED REPAIR TIME (HOURS)	FINAL RELIABILITY
CS 89	2	0	0	3	21.00	0	4200	3.0	.9999934
CS 90	2	0	0	0	.00	0	0	.0	1.0000000
CS 91	4	0	0	0	.00	0	0	.0	1.0000000
CS 91	2	0	0	3	9.00	0	4200	3.0	.9999987
CS 92	2	0	0	0	.00	0	0	.0	1.0000000
CS 93	2	0	0	0	.00	0	0	.0	1.0000000
CS 93	2	0	0	3	21.00	0	4200	3.0	.9999987
CS 94	2	0	0	0	.00	0	0	.0	1.0000000
CS 95	2	0	0	0	.00	0	0	.0	1.0000000
TOTALS:					859.00	0	2448698	128.3	.9998024

SUBSYSTEM EP - ELECTRICAL POWER

COMPONENT NUMBER	BASIC COMPONENT POPULATION	PARALLEL ADDITIONS	STANDBY ADDITIONS	SPARE ADDITIONS	ADDED WEIGHT (POUNDS)	ADDED COST (DOLLARS)	ADDED VOLUME (CENTIMETERS)	ADDED REPAIR TIME (HOURS)	FINAL RELIABILITY
EP 1	2	0	0	0	.00	0	0	.0	1.0000000
EP 2	2	10	0	0	2.00	0	1000	.0	.9999993
EP 3	10	30	0	0	6.00	0	3000	.0	.9999991
EP 4	2	0	0	0	.00	0	0	.0	1.0000000
EP 4	1	0	0	2	690.00	0	290000	5.0	.9996956
EP 5	3	0	0	0	.00	0	0	.0	1.0000000
EP 5	1	0	0	2	2.00	0	6000	3.0	.9999999
EP 7	6	6	0	0	60.00	0	48600	.0	.9999616
EP 7	6	6	0	11	85.00	0	68000	14.3	.9999106
EP 7	12	12	0	22	170.00	0	119000	26.6	.9998039
EP 7	12	12	0	33	112.50	0	90000	42.9	.9998967
EP 8	6	6	0	0	132.00	0	196800	.0	.9995437
EP 8	12	12	0	45	654.00	0	584000	67.5	.9995062
EP 8	12	12	0	37	392.00	0	490000	55.5	.9996590
EP 8	18	18	0	57	375.00	0	375000	65.5	.9996660
EP 9	3	0	0	4	92.40	0	100400	4.0	.9999916
EP 10	16	16	0	0	83.20	0	32600	.0	.9999510
EP 11	3	0	0	3	51.30	0	24030	3.0	.9999773
EP 12	3	3	0	0	18.30	0	7410	.0	.9999908
EP 13	3	0	0	4	24.40	0	26400	4.0	.9999916
EP 14	3	0	0	2	6.20	0	11700	3.0	.9999970
EP 15	1	0	0	3	47.10	0	48300	6.0	.9999659
EP 16	1	0	0	2	.20	0	200	4.0	1.0000000
EP 17	10	0	0	2	10.00	0	8700	3.0	.9999991
EP 18	200	0	0	6	.78	0	300	3.0	.9999999
EP 19	100	0	0	5	1.50	0	500	15.0	1.0000000
EP 20	2	0	0	1	25.20	0	26600	4.0	.9999939
EP 21	2	0	0	0	.00	0	0	.0	1.0000000
EP 22	1	0	0	0	.00	0	0	.0	1.0000000
TOTALS:					3071.08	0	2058740	351.3	.9975441

SUBSYSTEM IF - INFLIGHT TEST SYSTEM

COMPONENT NUMBER	BASIC COMPONENT POPULATION	PARALLEL ADDITIONS	STANDBY ADDITIONS	SPARE ADDITIONS	ADDED WEIGHT (POUNDS)	ADDED COST (DOLLARS)	ADDED VOLUME (CENTIMETERS)	ADDED REPAIR TIME (HOURS)	FINAL RELIABILITY
IF 1	250	0	0	7	.42	0	28	3.5	1.0000000
IF 2	80	0	0	4	.52	0	64	3.6	.9999996
IF 3	60	0	0	4	.24	0	16	1.2	.9999999
IF 4	200	0	0	7	.42	0	28	2.1	1.0000000
IF 5	170	0	0	7	.14	0	14	2.1	1.0000000
IF 6	30	0	0	19	16.72	0	247	.7	1.0000000
IF 7	4	0	0	5	1.65	0	250	4.0	.9999995
IF 8	6	0	0	5	1.30	0	200	3.5	.9999999
IF 9	8	0	0	7	2.31	0	350	5.6	.9999999
IF 10	12	0	0	6	1.56	0	240	4.2	.9999997
IF 11	22	0	0	17	4.42	0	850	.7	1.0000000
IF 12	6	0	0	8	2.64	0	400	6.4	.9999997
IF 13	6	0	0	4	1.32	0	200	3.2	.9999999
IF 14	4	0	0	7	2.31	0	350	5.6	.9999992
IF 15	3	0	0	5	1.65	0	250	4.0	.9999989
IF 16	1	0	0	5	1.30	0	200	3.5	1.0000000
IF 17	1	0	0	4	1.32	0	200	3.2	.9999999
IF 18	1	0	0	5	1.30	0	250	4.0	1.0000000
IF 19	1	0	0	6	3.06	0	3600	4.2	.9999999
IF 20	1	0	0	4	.44	0	200	3.2	1.0000000
IF 21	1	0	0	2	.66	0	100	1.6	.9999991
IF 22	1	0	0	4	1.32	0	200	3.2	1.0000000
IF 23	1	0	0	7	7.00	0	7000	6.3	.9999992
IF 25	1	0	0	12	12.00	0	14400	.0	.9999965
IF 26	1	0	0	4	1.76	0	400	2.8	.9999999
IF 27	1	0	0	5	1.30	0	200	3.5	1.0000000
IF 28	1	0	0	5	1.30	0	200	3.5	1.0000000
IF 29	1	0	0	6	1.56	0	240	4.2	.9999999
IF 30	1	0	0	2	22.00	0	20000	5.0	.9999810
IF 31	1	0	0	2	29.50	0	6400	3.0	.9999985
IF 32	1	0	0	2	27.80	0	28400	5.0	.9999810
IF 33	1	0	0	3	66.00	0	21000	4.5	.9999964
IF 34	1	0	0	2	20.00	0	20000	2.4	.9999990
IF 35	1	0	0	2	20.00	0	20000	2.4	.9999990
IF 36	1	0	0	2	20.00	0	20000	3.0	.9999921
IF 37	1	0	0	2	40.00	0	22800	2.0	.9999389
IF 38	1	0	0	3	36.00	0	12600	4.5	.9999964
IF 39	1	0	0	4	36.00	0	6560	4.0	.9999671
TOTALS:					387.34	0	208537	129.4	.9998398

SUBSYSTEM LS - ENVIRONMENTAL CONTROL/LIFE SUPPORT SYSTEM

COMPONENT NUMBER	BASIC COMPONENT POPULATION	PARALLEL ADDITIONS	STANDBY ADDITIONS	SPARE ADDITIONS	ADDED WEIGHT (POUNDS)	ADDED COST (DOLLARS)	ADDED VOLUME (CENTIMETERS)	ADDED REPAIR TIME (HOURS)	FINAL RELIABILITY
LS 101	2	2	0	11	31.20	0	85800	13.2	.9999906
LS 102	2	0	0	2	2.60	0	21400	2.0	.9999998
LS 103	[illegible]	0	0	3	6.00	0	2400	3.0	.9999999
LS 104	2	0	2	14	84.40	0	106360	28.0	.9999756
LS 105	4	0	0	2	2.00	0	1640	2.0	.9999985
LS 106	2	0	0	2	2.60	0	1640	3.0	.9999998
LS 107	2	0	0	7	112.00	0	264600	14.0	.9999910
LS 108	2	0	0	2	2.60	0	21400	4.0	.9999998
LS 109	4	0	0	2	7.00	0	2600	2.0	.9999985
LS 110	16	0	0	1	.40	0	650	1.0	.9999986
LS 111	2	0	2	3	33.30	0	35960	6.0	.9999821
LS 112	2	2	0	1	3.00	0	12900	.5	.9999936
LS 113	2	2	0	0	30.00	0	197000	.0	.9999450
LS 114	2	0	2	10	112.40	0	295960	15.0	.9999543
LS 115	2	0	0	0	.00	0	0	.0	1.0000000
LS 201	4	4	0	8	192.00	0	187000	66.0	.9997822
LS 202	4	4	0	8	228.00	0	155000	66.0	.9997822
LS 203	4	4	0	18	57.20	0	11550	27.0	.9999692
LS 204	4	4	0	21	25.00	0	6550	31.5	.9999366
LS 205	2	2	0	2	2.00	0	600	4.0	.9999363
LS 207	2	0	0	3	12.00	0	756	4.5	.9999953
LS 208	2	0	0	2	1.00	0	426	2.0	.9999998
LS 209	2	0	2	12	61.40	0	19420	24.0	.9999644
LS 210	8	8	0	39	23.50	0	24675	58.5	.9999866
LS 211	2	0	0	6	90.00	0	16800	12.0	.9999910
LS 213	2	2	0	1	15.00	0	10500	1.5	.9999724
LS 215	3	0	0	0	.00	0	0	.0	1.0000000
LS 301	3	0	0	2	13.00	0	16400	3.0	.9999998
LS 302	36	0	0	5	.50	0	250	5.0	1.0000000
LS 303	4	0	0	2	3.00	0	3280	1.0	.9999994
LS 304	4	0	0	7	168.00	0	103600	21.0	.9999847
LS 305	4	0	0	1	16.00	0	100000	3.0	.9999756
LS 306	12	0	0	3	6.00	0	2463	3.0	.9999985
LS 307	10	0	0	3	30.00	0	84900	9.0	.9999659
LS 308	4	4	0	15	885.00	0	2380000	144.0	.9966163
LS 309	8	0	0	11	11.00	0	7590	11.0	.9999975
LS 310	4	0	0	1	8.00	0	51000	3.0	.9999756
LS 311	4	0	0	11	11.00	0	1100	11.0	.9999977
LS 312	8	0	0	3	6.00	0	6150	3.0	.9999999

SUBSYSTEM LS PAGE 2

COMPONENT NUMBER	BASIC COMPONENT POPULATION	PARALLEL ADDITIONS	STANDBY ADDITIONS	SPARE ADDITIONS	ADDED WEIGHT (POUNDS)	ADDED COST (DOLLARS)	ADDED VOLUME (CENTIMETERS)	ADDED REPAIR TIME (HOURS)	FINAL RELIABILITY
LS 316	2	0	0	0	.00	0	0	.0	1.0000000
LS 318	32	0	0	3	.60	0	240	3.0	.9999999
LS 319	4	0	0	3	1.50	0	690	1.5	.9999990
LS 320	4	0	0	5	2.50	0	4100	5.0	.9999989
LS 321	5	0	0	7	2.00	0	1750	3.5	.9999992
LS 322	18	0	0	3	1.20	0	990	3.0	.9999990
LS 323	4	0	0	0	.00	0	0	.0	1.0000000
LS 324	4	0	0	0	.00	0	0	.0	1.0000000
LS 325	4	0	0	0	.00	0	0	.0	1.0000000
LS 325	2	0	0	2	10.00	0	10000	2.0	.9999999
LS 326	4	0	0	0	.00	0	0	.0	1.0000000
LS 327	2	0	0	0	.00	0	0	.0	1.0000000
LS 401	2	0	2	16	95.60	0	30480	24.0	.9999402
LS 402	6	8	0	33	4.10	0	3362	33.0	.9999973
LS 403	2	2	0	0	26.00	0	42600	.0	.9999450
LS 404	2	0	0	0	.00	0	0	.0	1.0000000
LS 405	2	2	0	0	32.00	0	49200	.0	.9999450
LS 406	2	2	0	9	11.00	0	1738	9.0	.9999943
LS 407	2	2	0	15	17.00	0	2686	15.0	.9999949
LS 408	4	4	0	21	25.00	0	3950	21.0	.9999666
LS 409	2	0	0	2	14.00	0	23000	2.0	.9999995
LS 410	2	0	2	15	43.94	0	22950	15.0	.9999353
LS 412	2	2	0	2	1.60	0	632	4.0	.9999985
LS 413	8	8	0	23	12.40	0	992	23.0	.9999397
LS 414	2	2	0	0	340.00	0	1313600	.0	.9999939
LS 415	4	0	0	2	.60	0	1600	1.0	.9999999
LS 416	4	4	0	0	32.00	0	74000	.0	.9998901
LS 417	4	4	0	5	16.00	0	56250	5.0	.9999738
LS 418	4	4	0	0	60.00	0	115200	.0	.9998901
LS 419	8	8	0	59	23.45	0	10566	59.0	.9999971
LS 420	2	0	0	0	.00	0	0	.0	1.0000000
LS 421	2	0	0	0	.00	0	0	.0	1.0000000
LS 422	2	0	0	0	.00	0	0	.0	1.0000000
LS 423	4	0	0	0	.00	0	0	.0	1.0000000
LS 423	2	0	0	1	3.00	0	3000	1.0	.9999939
LS 504	4	0	0	2	2.00	0	1000	2.0	.9999999
LS 509	4	0	0	5	7.50	0	2625	7.5	.9999946
LS 511	2	0	0	5	15.00	0	6150	10.0	.9999981
LS 512	8	0	0	6	3.00	0	3150	12.0	.9999997

SUBSYSTEM LS PAGE 3

COMPONENT NUMBER	BASIC COMPONENT POPULATION	PARALLEL ADDITIONS	STANDBY ADDITIONS	SPARE ADDITIONS	ADDED WEIGHT (POUNDS)	ADDED COST (DOLLARS)	ADDED VOLUME (CENTIMETERS)	ADDED REPAIR TIME (HOURS)	FINAL RELIABILITY
LS 513	2	6	0	0	30.00	0	9840	.0	.9999933
LS 514	2	0	0	2	1.20	0	400	1.0	.9999999
LS 515	2	0	0	1	1.60	0	350	.5	.9999939
LS 516	13	7	0	0	.00	0	0	.0	1.0000000
LS 515	1	1	0	0	1850.00	0	920000	.0	.9994129
LS 516	7	2	0	0	.00	0	0	.0	1.0000000
LS 514	1	1	0	0	1345.00	0	920000	.0	.9998063
LS 517	22	44	0	111	100.75	0	23250	333.0	.9999501
LS 518	22	22	0	44	11.60	0	17400	282.0	.9999923
LS 519	22	44	0	120	16.40	0	24600	300.0	.9999923
LS 520	22	44	0	92	143.10	0	15920	155.0	.9998937
LS 521	22	44	0	169	213.00	0	31950	422.5	.9999130
LS 522	22	66	0	172	71.40	0	30940	344.0	.9999935
LS 523	22	0	0	6	2.40	0	210	12.0	.9999999
LS 524	22	0	0	0	.00	0	0	.0	1.0000000
LS 525	2	0	0	0	.00	0	0	.0	1.0000000
LS 526	4	0	0	9	13.50	0	13500	9.0	.9999977
TOTALS:					6930.74	0	8035344	2728.2	.9962138

SUBSYSTEM ME - MAINTENANCE EQUIPMENT

COMPONENT NUMBER	BASIC COMPONENT POPULATION	PARALLEL ADDITIONS	STANDBY ADDITIONS	SPARE ADDITIONS	ADDED WEIGHT (POUNDS)	ADDED COST (DOLLARS)	ADDED VOLUME (CENTIMETERS)	ADDED REPAIR TIME (HOURS)	FINAL RELIABILITY
ME 1	1	0	0	0	.00	0	0	.0	1.0000000
ME 2	1	0	0	1	3.00	0	3000	2.0	.9999969
ME 3	1	0	0	1	8.00	0	14159	2.0	1.0000000
ME 4	1	0	0	2	18.00	0	4000	9.0	.9999994
ME 5	1	0	0	1	7.00	0	5100	2.0	1.0000000
ME 6	1	0	0	0	.00	0	0	.0	1.0000000
ME 7	1	0	0	1	1.10	0	500	2.0	1.0000000
ME 8	1	0	0	1	2.20	0	1000	2.0	1.0000000
ME 9	1	0	0	0	.00	0	0	.0	1.0000000
ME 10	1	0	0	0	.00	0	0	.0	1.0000000
ME 11	1	0	0	0	.00	0	0	.0	1.0000000
ME 12	1	0	0	0	.00	0	0	.0	1.0000000
ME 13	1	0	0	0	.00	0	0	.0	1.0000000
ME 14	1	0	0	1	2.00	0	500	2.0	1.0000000
TOTALS:					41.30	0	31259	21.0	.9999962

[illegible] - PROPULSION SYSTEM

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] (POUNDS)	[illegible]	[illegible]	[illegible]	FINAL RELIABILITY
PP	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible].70	[illegible]	136000	.0	.9999999
PP	[illegible]	[illegible]	[illegible]	[illegible]	15	[illegible].75	[illegible]	[illegible]	[illegible]	.9999497
PP	[illegible]	12	12	[illegible]	15	[illegible].75	[illegible]	1539	60.0	.9999597
PP	[illegible]	2	[illegible]	0	1	.25	0	1-2	2.0	1.0000000
PP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	566	.0	1.0000000
PP	[illegible]	2	[illegible]	[illegible]	1	.2[illegible]	0	57	2.0	1.0000000
PP	[illegible]	2	2	0	8	2.0[illegible]	[illegible]	1420	64.0	.9999991
PP	[illegible]	2	2	[illegible]	0	.5[illegible]	[illegible]	114	.0	1.0000000
PP	[illegible]	[illegible]	[illegible]	[illegible]	0	.5[illegible]	[illegible]	264	.0	1.0000000
PP	[illegible]	2	[illegible]	[illegible]	0	1.5[illegible]	[illegible]	284	.0	1.0000000
PP	[illegible]	1	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	.0	1.0000000
PP	[illegible]	1	[illegible]	0	0	.0[illegible]	[illegible]	0	.0	.9994745
PP	[illegible]	[illegible]	2	[illegible]	[illegible]	1.0[illegible]	[illegible]	114	.0	.9999994
PP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	284	.0	1.0000000
PP	[illegible]	[illegible]	[illegible]	0	[illegible]	.3[illegible]	[illegible]	0	.0	.9999965
PP	[illegible]	2	[illegible]	0	1	.05	[illegible]	25	2.0	1.0000000
PP	[illegible]	2	[illegible]	[illegible]	1	[illegible]	[illegible]	57	2.0	1.0000000
PP	[illegible]	[illegible]	[illegible]	[illegible]	0	10.[illegible]	[illegible]	566	.0	.9999997
PP	[illegible]	2	[illegible]	[illegible]	[illegible]	.0[illegible]	[illegible]	0	.0	.9997337
PP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.9999999
PP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.5[illegible]	[illegible]	114	.0	1.0000000
PP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.2[illegible]	[illegible]	264	.0	.9999999
PP	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	.0	1.0000000
PP	[illegible]	1	1	[illegible]	[illegible]	27.5[illegible]	[illegible]	14420	.0	.9999997
PP	[illegible]	12	12	0	[illegible]	3.0[illegible]	[illegible]	684	.0	1.0000000
PP	[illegible]	12	12	[illegible]	0	[illegible]	[illegible]	[illegible]	.0	1.0000000
PP	[illegible]	2	[illegible]	[illegible]	1	.25	[illegible]	142	2.0	1.0000000
PP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	565	.0	1.0000000
PP	[illegible]	[illegible]	[illegible]	0	1	.2[illegible]	[illegible]	57	2.0	1.0000000
PP	[illegible]	2	[illegible]	[illegible]	8	2.0[illegible]	0	25	64.0	.9999991
PP	[illegible]	2	[illegible]	0	0	.5[illegible]	0	114	.0	1.0000000
PP	[illegible]	2	[illegible]	0	[illegible]	[illegible]	[illegible]	284	.0	1.0000000
PP	33	[illegible]	[illegible]	[illegible]	0	1.5[illegible]	[illegible]	284	.0	1.0000000
PP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.0[illegible]	[illegible]	0	.0	1.0000000
PP	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.0	.9989494
PP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0[illegible]	0	114	.0	.9999994
PP	[illegible]	[illegible]	[illegible]	[illegible]	8	6.0[illegible]	[illegible]	1132	.0	1.0000000
PP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	.0	.9999965
PP	[illegible]	[illegible]	[illegible]	0	1	.05	[illegible]	43	2.0	1.0000000
PP	[illegible]	2	[illegible]	[illegible]	1	.10	[illegible]	57	2.0	1.0000000
PP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]	[illegible]	565	.0	.9999997
PP	[illegible]	2	[illegible]	0	1	1.09	0	283	4.0	1.0000000
TOTALS:						247.5[illegible]	0	296837	272.0	.9981268

SUBSYSTEM: SC - GUIDANCE AND CONTROL SYSTEM

COMPONENT NUMBER	BASIC COMPONENT POPULATION	PARALLEL ADDITIONS	STANDBY ADDITIONS	SPARE ADDITIONS	ADDED WEIGHT (POUNDS)	ADDED COST (DOLLARS)	ADDED VOLUME (CENTIMETERS)	ADDED REPAIR TIME (HOURS)	FINAL RELIABILITY
SC 1	1	0	0	6	122.40	0	33600	6.0	.9999917
SC 2	1	0	0	4	[illegible]	0	[illegible]	2.0	.9999571
SC 3	1	0	0	2	21.60	0	14000	1.0	.9999985
SC 4	1	0	0	4	90.40	0	50000	2.0	.9999671
SC 5	1	0	0	4	74.40	0	52500	2.0	.9999671
SC 6	1	0	0	4	93.60	0	112000	2.0	.9999671
SC 7	1	0	0	9	81.00	0	52200	.0	.9999642
SC 8	1	0	0	3	[illegible]	0	4500	3.0	.9999955
SC 9	1	0	0	2	14.40	0	4400	1.0	.9999992
SC 10	1	0	0	3	10.80	0	5700	3.0	.9999955
SC 11	2	8	0	0	40.00	0	22400	.0	.9999917
SC 12	2	6	0	0	3.60	0	3600	.0	.9999998
SC 13	1	3	0	0	21.00	0	45000	.0	.9999575
SC [illegible]	6	0	0	0	.00	0	0	.0	1.0000000
SC [illegible]	12	0	0	14	14.00	0	11900	14.0	.9999987
SC 17	24	0	0	3	3.00	0	2550	3.0	.9999980
SC [illegible]	12	0	0	4	46.00	0	14000	4.0	.9999500
SC 19	12	0	0	4	4.00	0	2000	2.0	.9999999
SC 20	6	0	0	3	174.00	0	150000	12.0	.9998130
SC 21	1	0	0	4	[illegible]	0	[illegible]	2.0	.9999671
SC 22	1	0	0	4	226.00	0	[illegible]	2.0	.9997837
SC 23	4	0	0	7	70.00	0	17500	3.5	.9999910
SC 24	1	3	0	0	[illegible]	0	[illegible]	.0	.9999336
SC 25	1	3	0	0	16.60	0	22200	.0	.9999986
SC 26	2	6	0	0	33.60	0	44400	.0	.9999972
SC 27	2	6	0	0	33.60	0	44400	.0	.9999972
SC [illegible]	2	8	0	0	12.00	0	17600	.0	.9999972
SC 30	4	12	0	0	7.20	0	10800	.0	.9999996
SC 31	4	12	0	0	7.20	0	10800	.0	.9999996
SC 32	4	12	0	0	12.00	0	14400	.0	.9999996
SC 33	2	6	0	0	[illegible]	0	7200	.0	.9999998
SC 34	2	8	0	0	8.00	0	12000	.0	.9999993
SC 35	3	0	0	0	.00	0	0	.0	1.0000000
SC [illegible]	1	1	0	0	[illegible]	0	[illegible]	.0	.9999578
SC [illegible]	3	0	0	0	.00	0	0	.0	1.0000000
SC 36	1	1	0	0	+51.00	0	67000	.0	.9999578
SC 37	2	2	0	0	[illegible]	0	[illegible]	.0	.9999339
SC [illegible]	1	1	0	5	+38.00	0	84000	200.0	.9999396
SC [illegible]	3	0	0	7	21.00	0	21000	70.0	.9999982
SC [illegible]	3	0	0	7	21.00	0	21000	70.0	.9999982
SC [illegible]	3	0	0	6	18.00	0	18000	60.0	.9999986
SC 42	1	0	0	1	62.00	0	60000	20.0	.9998483
TOTALS:					2678.10	0	2106150	464.5	.9990722